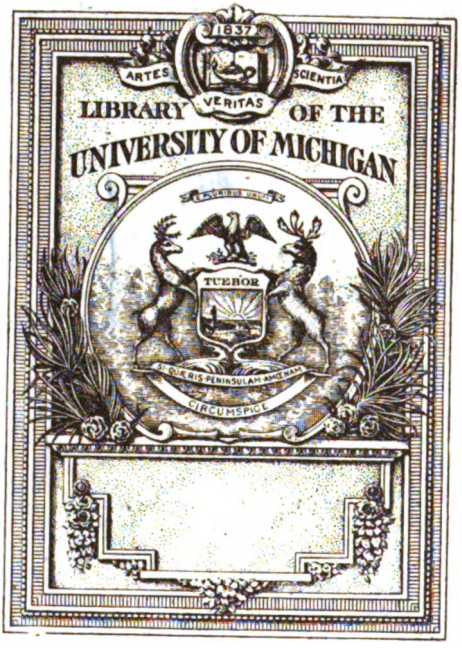


NINTH ANNUAL REPORT

OF THE

STATE ENTOMOLOGIST

OF INDIANA.

FRANK N. WALLACE

1915-1916

FORT WAYNE PRINTING COMPANY
CONTRACTORS FOR STATE PRINTING AND BINDING
1917

THE STATE OF INDIANA,
EXECUTIVE DEPARTMENT,
May 20, 1917.

Received by the Governor, examined and referred to the Auditor of State for verification of the financial statement.

OFFICE OF AUDITOR OF STATE,
May 20, 1917.

The within report, so far as the same relates to moneys drawn from the State Treasury, has been examined and found correct.

OTTO L. KLAUSS,
Auditor of State.

May 21, 1917.

Returned by the Auditor of State, with above certificate, and transmitted to the Secretary of State for publication, upon the order of the Board of Commissioners of Public Printing and Binding.

FRANK P. LITSIBERT,
Secretary to the Governor.

Filed in the office of the Secretary of State of the State of Indiana. May 29. 1917.

ED. JACKSON,
Secretary of State.

Received the within report and delivered to the printer June 26, 1917.

DIRRELLE CHANEY,
Clerk Printing Board.

LETTER OF TRANSMITTAL

OFFICE OF STATE ENTOMOLOGIST,

FRANK N. WALLACE.

INDIANAPOLIS, INDIANA, May 4, 1917.

HONORABLE JAMES P. GOODRICH, *Governor of Indiana*.

It is with pleasure that I herewith submit the Ninth Annual report of the State Entomologist's office.

In this report several pests new to Indiana are described and illustrated in detail.

I have endeavored to make this issue as practical as possible for the people into whose hands it is intended to go. The accompanying illustrations are considered essential for a clear and concise understanding of the text.

A part of this report is devoted to the department of bee inspection.

Very respectfully,

FRANK N. WALLACE,
State Entomologist.

FINANCIAL STATEMENT OF STATE ENTOMOLOGIST.

For Fiscal Year October, 1915, to September 30, 1916.

Appropriation		$15,000.00
Salaries:—		
F. N. Wallace, State Entomologist	$2,500.00	
Clerks and Deputies	8,431.91	
Miscellaneous, Office and Laboratory Expenses	508.71	
Freight and Express	52.53	
Telephone and Telegraph	147.48	
Postage	594.00	
Traveling Expenses	2,759.23	
Total expenditures	$14,993.86	
Credit returned to state	6.14	
	$15,000.00	$15,000.00

An itemized account of the above expenditures is on file with the Auditor of State.

License Fund—

Fees received for licenses issued to Nurserymen, Dealers and Agents, engaged in selling nursery stock:

Balance October 1, 1915	$324.00
Receipts for current year	1,069.00
	$1,393.00
Expenditures	1,053.00
Balance on hand October 1, 1916	$340.00

INDIANA NURSERYMEN.

Name.	Address.	Kind of Certificate Issued.
Abraham Brothers.....	Martinsville, Indiana...	General Nursery Stock.
Allen, Chas. B.....	West Baden, Indiana...	Small Fruit Plants.
Allison Bros., Fruit Farm	Columbus, Indiana....	Small Fruit Plants.
Allstott, J. W.....	Corydon, Indiana.....	General Nursery Stock.
Arnold, Glen.....	Danville, Indiana.....	General Nursery Stock.
Atkinson, Roy.....	Fowler, Indiana.....	General Nursery Stock.
Ault, Henry A.....	Columbus, Indiana....	General Nursery Stock.
B.		
Beck, E. H.....	Michigan City, Indiana	Small Fruit Plants.
Bennett, A. S.....	LaFayette, Indiana....	General Nursery Stock.
Bennett, J. W.....	Doans, Indiana.....	General Nursery Stock.
Bennett, Mrs. M. C. & Sons.....	Grandview, Indiana....	Small Fruit Plants.
Bierly, Otis.....	Borden, Indiana.....	Strawberry Plants.
Blankenbaker, E. E.....	Borden, Indiana.....	Blackberry and Strawberry Stock.
Bonames, G. W.....	Milltown, Indiana.....	General Nursery Stock.
Brandywine Nurseries...	Greenfield, Indiana....	General Nursery Stock.
Bremen Nursery Co....	Bremen, Indiana.....	General Nursery Stock.
Billingsley, S.....	Greenwood, Indiana...	General Nursery Stock.
Brenneman, Moody.....	Berne, Indiana.....	General Nursery Stock.
Buckskin Nursery Co...	Elberfield, Indiana.....	General Nursery Stock.
Burns City Nursery....	Burns City, Indiana...	General Nursery Stock.
Burkhardt's Nursery....	Indianapolis, Indiana..	General Nursery Stock.
Burkhardt, H. A.....	Indianapolis, Indiana..	Shade Trees and Ornamentals.
C.		
Cain, W. D.....	Shelburn, Indiana.....	Small Fruit Plants.
Callahan, P. H.....	Pekin, Indiana.....	Blackberry Plants.
Cathcart, A. Y.....	Bristol, Indiana.....	General Nursery Stock.
Centerville Nurseries....	Centerville, Indiana....	General Nursery Stock.
Childers, G. W.....	Valeene.....	General Nursery Stock.
Coats, John.....	Borden, Indiana.....	Small Fruit Plants.
Collins, Lamar.....	Underwood, Indiana...	General Nursery Stock.
Cook, J. L.....	Warsaw, Indiana.....	Strawberry Plants.
Cutler, L. D.....	Warsaw, Indiana.....	General Nursery Stock.
Cunningham Nursery Co.	Seymour, Indiana.....	General Nursery Stock.
D.		
Davis, Geo.....	Brazil, Indiana.....	Small Fruit Plants.
Doans, J. L.....	Westfield, Indiana.....	Ornamentals.

INDIANA NURSERYMEN—Continued.

NAME.	ADDRESS.	KIND OF CERTIFICATE ISSUED.
E.		
Erwin, T. J.	Mount Vernon, Indiana	Chestnut & Pecan Trees.
Everetts, J. W.	Hamilton, Indiana	General Nursery Stock.
F.		
Favorite Nursery Co.	Granger, Indiana	General Nursery Stock.
Fairview Gardens	Elnora, Indiana	Catalpa Trees.
Flarg, A. E. & Sons	Logansport, Indiana	Small Fruit Plants.
Fonner, W. A.	Decatur, Indiana	Strawberry Plants.
Fullhart, Chas.	Muncie, Indiana	General Nursery Stock.
Furnas, I. Chalmers	Mooresville, Indiana	Small Fruit Plants.
G.		
Geiser, H. L.	Seymour, Indiana	General Nursery Stock.
Goss, D. L.	Borden, Indiana	Small Fruit Plants.
Goehler, Albert	Urbana, Indiana	General Nursery Stock.
Graham, Chas. F.	Jeffersonville, Indiana	General Nursery Stock.
Garber, D. M. & Son	Princeton, Indiana	Small Fruit Plants.
Gray, D. M.	Borden, Indiana	Small Fruit Plants.
Gray's Nursery	Salem, Indiana	General Nursery Stock.
H.		
Halbrook, Wm.	Evansville, Indiana	General Nursery Stock.
Haas Nurseries	Terre Haute, Indiana	General Nursery Stock.
Harrington, F. A.	Gilead, Indiana	Strawberry Plants.
Henby, J. K. & Sons	Greenfield, Indiana	General Nursery Stock.
Hallick, Chas.	Fair Oaks, Indiana	General Nursery Stock.
Hobbs, Franklin	Osceola, Indiana	Barberry Plants.
Hobbs, C. M. & Sons	Bridgeport, Indiana	General Nursery Stock.
Home Nursery	Hatfield, Indiana	General Nursery Stock.
Horton, Eugene	Wagoner, Indiana	General Nursery Stock.
Hoosier Rose Co.	New Castle, Indiana	Rose Stock.
Howe & Stanfield	Scipio, Indiana	General Nursery Stock.
Hill, E. G., & Co.	Richmond, Indiana	Rose Stock.
Humfeld, Simon	Muncie, Indiana	Ornamental Stock.
I.		
Indiana Nut Nursery	Rockport, Indiana	Pecan and Walnut Trees.
Indianapolis Flower & Plant Co.	Indianapolis, Indiana	Ornamentals.
J.		
Jackman, H. E.	Waterloo, Indiana	General Nursery Stock.
Jackson, Hamilton	Borden, Indiana	Small Fruit Plants.
Jarrett, J. A.	Keystone, Indiana	Shade Trees.

INDIANA NURSERYMEN—Continued.

NAME.	ADDRESS.	KIND OF CERTIFICATE ISSUED.
K.		
Kankakee Valley Nurseries	Walkerton, Indiana	General Nursery Stock.
Kemp, Eben	Martinsville, Indiana	Peach Trees.
Kellum, R. S	Clay City, Indiana	Strawberry Plants.
Kreider Nurseries	Middlebury, Indiana	General Nursery Stock.
L.		
LaHayne, Wm	Chesterton, Indiana	General Nursery Stock.
LaFayette Nurseries	LaFayette, Indiana	General Nursery Stock.
Littlepage, T. P	Booneville, Indiana	Nut Trees.
Long, T. A	Elnora, Indiana	Small Fruit Plants.
Lykens, Henry	Westfield, Indiana	Small Fruit Plants.
M.		
M. M. Co., The Nursery	Columbia City, Indiana	General Nursery Stock.
Maheuron, Grover T. & G. D.	Pekin, Indiana	Small Fruit Plants.
Martindale, Moses	Doans, Indiana	Apple & Cherry Stock.
Mays, W. H	Goshen, Indiana	General Nursery Stock.
Meeker & Rockwell	Crown Point, Indiana	General Nursery Stock.
Merrill, H. R	Brownstown, Indiana	General Nursery Stock.
Moyer, G. N	Laketon, Indiana	General Nursery Stock.
Moffett, Frank	Carmel, Indiana	Small Fruit Plants.
Murry, A. M	Goshen, Indiana	General Nursery Stock.
Maplewood Floral Co	South Bend, Indiana	General Nursery Co.
McClaran, Chas	Ramsey, Indiana	General Nursery Stock.
McCoy, R. L	Lake, Indiana	General Nursery Stock.
McElderry, W. E	Princeton, Indiana	General Nursery Stock.
McCormick, Chas	Burns City, Indiana	General Nursery Stock.
N.		
National Fruit & Plant Farm	Gilead, Indiana	Strawberry Plants.
Noble, J. M	Sellersburg, Indiana	Small Fruit Plants.
New Albany Nursery	New Albany, Indiana	Peach & Shade Trees.
Nut, Geo. W	Valparaiso, Indiana	Apple & Strawberry–Stock.
O.		
Ooley, Bert	Borden, Indiana	Small Fruit Plants.
Osborn, Jas. T	Burns City, Indiana	Small Fruit Plants.
P.		
Palmer, Fred L	Indianapolis, Indiana	General Nursery Stock.
Plotner, S. C	Mishawaka, Indiana	Strawberry Plants.
Polhamus, A. Z	Fort Wayne, Indiana	Small Fruit Plants.
Portland Nursery Co.	Portland, Indiana	General Nursery Stock.

INDIANA NURSERYMEN—Continued.

NAME.	ADDRESS.	KIND OF CERTIFICATE ISSUED.
Q.		
Quillen, Chas	Mooresville, Indiana	Small Fruit Plants.
R.		
Ragle, Amos	Elnora, Indiana	General Nursery Stock.
Rathburn, L. G	Orland, Indiana	Small Fruit Plants.
Reed, W. H	Hanover, Indiana	General Nursery Stock.
Reed, W. C	Vincennes, Indiana	General Nursery Stock.
Richland Nurseries	Bloomfield, Indiana	General Nursery Stock.
Ridge Fruit Farm	Larwill, Indiana	Small Fruit Plants.
Ridge Nursery	Tobinsport, Indiana	General Nursery Stock.
Rigo Nurseries	Paoli, Indiana	General Nursery Stock.
Roerk, F. M	Borden, Indiana	Blackberry Stock.
Roerk, T. J	Borden, Indiana	Small Fruit Plants.
S.		
Shields, Thos	Anderson, Indiana	General Nursery Stock.
Shields Bros. Nursery Co.	Charlottsville, Indiana	General Nursery Stock.
Smith, J. E	Muncie, Indiana	General Nursery Stock.
Simpson, H. M. & Sons	Vincennes, Indiana	General Nursery Stock.
Shoemaker, W. A	Spencer, Indiana	Peach Trees & Small Fruit Plants.
Stemple, Chas. K	Richmond, Indiana	General Nursery Stock.
Strite, Chas	Butler, Indiana	Small Fruit Plants.
Sturn, Chas. C	Elizabeth, Indiana	General Nursery Stock.
Stuart & Haugh	Anderson, Indiana	General Nursery Stock.
Silver, Milo	Columbus, Indiana	General Nursery Stock.
South Bend Plant Co	South Bend, Indiana	Small Fruit Plants.
Sunshine Nurseries	Corydon, Indiana	General Nursery Stock.
T.		
Tate, Jacob	Mexico, Indiana	Strawberry Plants.
Todd, H. A., Fruit Farm	Bedford, Indiana	Small Fruit Plants.
Thornburgh, G. A	Evansville, Indiana	Shade Trees & Ornamentals.
W.		
Walts, W. C	Pennville, Indiana	Strawberry Plants.
Weber, C. H	Greenfield, Indiana	General Nursery Stock.
Whicker, Otto	Amo, Indiana	General Nursery Stock.
Wheaton, Everett	Mt. Liberty, Indiana	Peach Trees.
White, Harry	North Manchester, Indiana	Greenhouse Stock.
Wilson, Elias	Carmel, Indiana	Small Fruit Stock.
Wiltshire, L. C	Winona Lake, Indiana	Strawberry Plants.
Walker, F. & Co	New Albany, Indiana	General Nursery Stock.

INTRODUCTION.

OUR INSECT PESTS

The loss caused by destructive insect pests assumes almost unbelievable proportions. The Government Expert C. L. Marlatt made an estimate in 1909 of the loss caused by insect pests alone and the summary as published in E. Dwight Sanderson's book "Insect Pests of Farm Garden and Orchard" is given here.

ANNUAL VALUES OF FARM PRODUCTS AND LOSSES CHARGEABLE TO INSECT PESTS*

Product	Values	Percentage of Loss	Amount of Loss
Cereals	$3,000,000,000	10	$300,000,000
Hay and forage	665,000,000	10	66,500,000
Cotton	850,000,000	10	85,000,000
Tobacco	100,000,000	10	10,000,000
Truck crops	300,000,000	20	150,000,000
Sugar	95,000,000	10	9,500,000
Fruits	150,000,000	20	30,000,000
Farm forests	110,000,000	10	11,000,000
Miscel aneous crops	100,000,000	10	10,000,000
Animals products	3,000,000,000	10	300,000,000
Total	$8,370,000,000		$972,000,000
Natura forests and forest products			$100,000,000
Products in storage			200,000,000
Grand total			$1,272,000,000

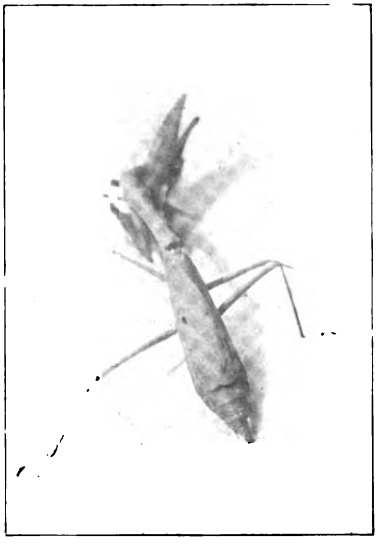
Based upon table of C. L. Marlatt, l.c., modified by statistics of the Secretary of Agriculture, Yearbook U. S. Department of Agriculture for 1909.

The totals are stupenduous and along many lines they are increasing yearly. As the value of the crops increase that part which is destroyed should likewise be given a higher valuation

*Estimated.

and it becomes more evident that we must exert greater effort to curtail this waste. It is easily understood why so many people consider every insect an enemy when they see not only crops but even flowers and shrubs planted around their homes destroyed by hordes of devastating insects.

To this great loss caused by the destruction of insects must be added the money and time now spent in fighting them. This in itself is assuming enormous proportions but it must be remembered that every dollar so spent will return many times over in increased crops. We shall never be able to wholly exterminate them but as more practical methods are worked out and these adopted by the growers the losses will gradually decrease. So much information of a scientific nature written in technical terms has been sent out to growers that it has caused most of them to look with suspicion upon anything that has the appearance of being "Scientific".



PRAYING MANTIS

One of the strange insects which is often sent to this office for identification. It is here shown feeding on a live grasshopper.

The work of this office places us in direct contact with the ones who have no scientific training, and information must be given which will enable them to go home and carry out the instructions. During the past year there were thousands of people who came to the office seeking help. Many of these desired information upon the common pests of farm, garden and household, and others had some very strange pests which none connected with the office had ever seen. However, these people had their troubles solved or at least were given the information which had been written about these pests.

Just one instance which happened last spring will well illustrate the point I am trying to make in regard to the application of scientific knowledge: Mr. Heller a rose grower of New Castle had been troubled with Rose midge and according to his statement had lost $6,000.00 up to that time from this pest and

had not been able to produce any roses from six of his houses. He wanted to know what he could do to save his roses or whether he should abandon those six houses for the balance of the season. The papers on the subject stated the life cycle of the insect was fifteen days from egg to adult, two days as egg, 5 to 7 days as larvæ working in the tender buds and six days in the pupæ stage in the soil. This was valuable information but the control recommended was sterlizing the soil with live steam. In a small space this could be done but in six houses and these with no partitions to separate them was an impossibility and both he and I knew it. I asked him if he would be willing to fumigate every night for fifteen nights with tobacco fumes and explained that if the adult flies were destroyed each day for fifteen days they would all be killed at the end of that time and no more could come later as with a fifteen day life cycle all would be hatched and the fumigation each evening would kill the adults before they had time to lay eggs. He saw how practical the recommendation was and started fumigating that night and had no trouble the balance of the season. He also stated later that he sold $8,000.00 worth of roses from those six houses after we gave him the directions as to what should be done.

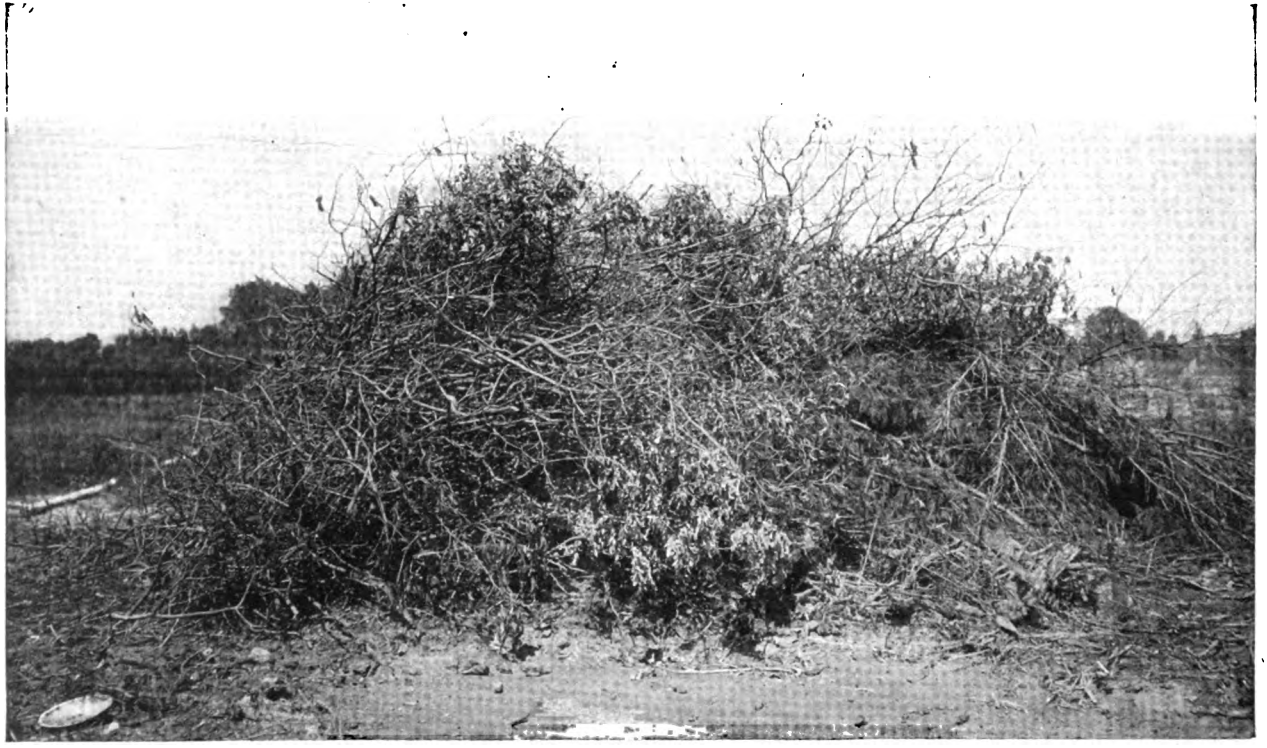
He also succeeded in convincing some of the other growers of New Castle that they too could control the midge by tobacco fumes and assured us that at least $25,000.00 was saved to the growers there last season. So it is not only the scientific knowledge that is necessary; it is the application of that knowledge in a practical manner which brings results. A man must be shown where he is to get more in return than what he spends before he will try any new methods.

The systematic study of the life history of our pests is absolutely essential to the proper working out of control methods. Yet it is neither necessary nor advisable to put all the data gathered and the methods which were used to collect that data into a publication which goes to the grower. He will seldom read it through and often when he does, the information he desires is so scattered throughout the work that he is not able to retain the points as he goes along, also many are published which only give a record of the work as a scientific basis for others to work upon and the cost of control was not considered. Needless to say most growers are not interested in these. They are of value only to other scientific men working upon the same species.

NURSERY INSPECTION

Most of the nurseries in Indiana this year were found in excellent condition. A few whose stock was poor, or had not conducted their business honorably were refused certificates and forced to quit business. All inferior stock was ordered destroyed before certificates were issued. Indiana Nursery firms grow and sell as good and as clean stock as can be grown and produced, and it is recognized as a standard. Since the State Entomologist's office was established, nine years ago, no serious insect pest or fungus disease has been spread from Indiana nurseries. A few have been brought into the State on nursery stock shipped in from other states, but these were discovered in time and thoroughly cleaned up. The Chestnut Blight, which came into Indiana from the state of Pennsylvania, was checked up on all the shipments which could be traced and all diseased trees were destroyed.

The Indiana nurserymen, with very few exceptions, gladly co-operate with the office in the eradication of any and all pests. A very few still feel that they would rather do business without any restrictions, but if they do not comply with instructions willingly they are required to do as we suggest before we issue certificates entitling them to do business. The accompanying illustration shows a "brush pile" at a nursery, made from a part of a season's culling of trees which were not considered good enough for sale. This causes considerable loss to the nurserymen, but it insures the growers the best grade of stock. Years ago unscrupulous dealers bought up these brush piles and after shipping them to their own place sorted the trees over and filled orders out of what was found in the pile. Needless to say any person buying this kind of stock could not get the varieties which were ordered, and they also received many diseased trees. This explains why so many Indiana orchards, which were planted from ten to twenty years ago contained such a conglomerate mixture of varieties. Hundreds of orchards in Indiana today do not have a single tree of the variety ordered, and in many cases no two trees of one variety stand together. The nursery men and dealers who did that class of work were rapidly put out of business and now we find all orchards coming true to name. Owners do not now have any fear of finding a badly mixed lot of trees or a great number of worthless varieties when they come into bearing.



BRUSH PILE AT NURSERY SHOWING DISCARDED TREES

One Indiana nurseryman, who was refused a certificate this year, had been selling peach trees for several years, which were not the variety he represented them to be. He claimed to have a very superior peach; that the quality was the best possible; that it was an excellent shipper, and a very regular and heavy bearer. Wherever the peaches were exhibited their size and quality attracted attention, and the man had no difficulty selling trees at an exorbitant price. Customers were informed that his trees were budded from the original tree, the tree which produced the peaches on exhibition.

Upon investigation I found he was not propagating this variety in sufficient quantity to supply his trade. In fact he was making no effort to do so, but was buying peach trees from other nurseries and filling orders for this special peach from these trees. This was a plain case of misrepresentation of stock, and he was refused a nursery certificate and had to stop selling nursery stock in Indiana. The only excuse this man had to offer for substituting another variety for the one he offered for sale, was that other nurserymen were trying to secure some of his trees and propagate them for their own use. By selling everybody another variety he felt sure that no nurserymen could secure any of his original stock and thus be able to supply this variety of peach trees to their customers.

IMPORT INSPECTION

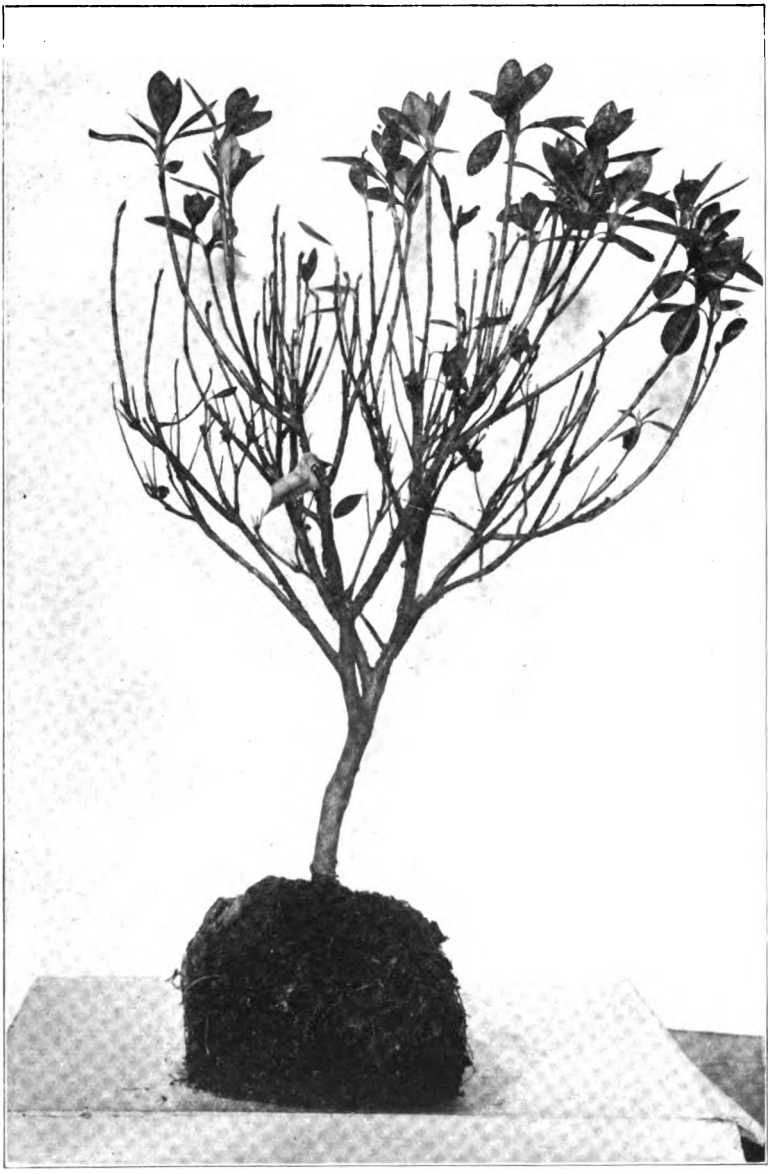
The inspection of all foreign grown nursery stock and plants has been done under the supervision of this office. This includes nusery stock of any description which is imported by nurserymen, stores, or private individuals, as well as the shrubs and plants which the florists import for forcing during the holiday season.

During the past season there were imported into Indiana 1,300,000 plants, shrubs and trees, and as each one of these had to be handled and examined carefully for insect pests and diseases it cost heavily in time and money. Since this work was taken up by the office many insect pests have been intercepted. The Federal Horticultural Board has done very effective work in getting the entomologists of foreign countries to give closer inspection on all shipments to the United States, and there has been great improvement in the condition of the stock as far as insect and disease conditions are concerned.

The seriousness of allowing all these plants to be imported into this country is now being realized by some of the entomologists, and an effort will soon be made to stop, or at least curtail the danger of having new pests and diseases introduced here. Most of the florists in Indiana state they have made little, or no profit on imported plants during the past few years, and that they would welcome a law which would prohibit the importation of plants, except such as the Department of Agriculture would deem advisable for propagation. Such a law would necessarily have to apply to all the states alike; as no one state could enact this law without working a hardship upon the firms within its borders. Most of the stock which is now imported could be grown in this country, and in different states where climatic conditions are favorable, we find our growers propagating this stock in increasing quantities.

Until a few years ago imported nursery stock was purchased only by nurserymen. Now foreign growers solicit business from private individuals, department stores and from all available sources.

When a nurseryman receives a foreign shipment almost the entire amount is planted on his place and grown for at least one season. In this manner any insect pest or disease which might have passed the inspector's eye would be found in the regular nursery inspection work the following year. Also the nurserymen



AZALEA INDICA

Imported from Holland, showing the ball of earth on the roots that comes over with the plant. A fungus disease called Exobasidium is also shown.

are constantly searching for pests and diseases, and as native pests are known to them they report to this office any which seem strange.

When privates estates buy direct from the importer, the stock is usually planted in its permanent location and this gives us no chance to watch the stock to see that nothing has escaped notice. The same holds true of the stores; the stock is examined and is then sold to individuals and planted by them. In this manner any disease which might be in an incipient stage, and thus overlooked, could easily gain a foothold in the state.

Many thousands of plants come in with a ball of earth around the roots, as the accompanying picture shows. It is impossible to tell what insects this contains, and at any time there is a possibility of having dangerous insect pests started in Indiana from this condition.

The Federal Horticultural Board renders every assistance possible by sending notices to the departments in the different states which have charge of the inspection work. The firms who have charge of the importations from foreign countries are also required to send notices to the collaborator of the Federal Horticultural Board in the different states. The cuts illustrate the nature of these notices, and also show how the reports must be filled out and then signed by the entomologist and returned to Washington.

Indiana's work along this line has always been satisfactory to the department at Washington. However, this State feels that the lines must be drawn closer on the importation of these plants, and that eventually importations must be prohibited.

When we consider the millions which have been spent fighting the Brown Tail and Gypsy Moth pests, Chestnut Blight and White Pine Blister rust, and then realize that these are only four out of hundreds, and that every year we have new ones to combat, it is time some legislation was enacted to check this destruction. Any profits the florists or nurserymen have made from import stock has been spent many times over each year by the States and Government in trying to control the pests and diseases which have been carried here from other countries. It can only be a control, for it can never be wholly eradicated when once they gain such a foothold as the Chestnut Blight now has in this country. At best it can only be confined to certain areas and as long as any of the native chestnut trees remain in those areas they will be a constant menace to the remainder of the

NOV 9 - 1916

UNITED STATES DEPARTMENT OF AGRICULTURE,
FEDERAL HORTICULTURAL BOARD,
WASHINGTON, D. C.

IMPORTER OR BROKER'S REPORT TO THE STATE INSPECTOR.

In compliance with Section 2 and Regulation 8 of the Plant Quarantine Act of August 20, 1912, the information provided for in this blank must be mailed by the person receiving the imported nursery stock at port of entry to the State Inspector of the State to which the stock is consigned *immediately* upon entry of nursery stock and *before* such stock is removed or shipped from port of entry. The port of entry is understood to be the port where the stock is cleared from customs and the duty paid. This information is required in the case of *each* separate shipment of imported nursery stock.

State inspectors are respectfully requested to notify the Federal Horticultural Board of the arrival of any imported nursery stock not reported to them as above indicated.

D. F. HOUSTON,
Secretary of Agriculture.

NOV 6 1916, 191

THE STATE INSPECTOR,

.....

The following nursery stock imported under Permit No. 538-,

consigned NEW YORK MALTUS & WARE
(Name of importer or broker at port of entry.)

will be forwarded on or about NOV 8 1916, 191

to Fred Lemon, florist, Richmond, Ind
(Port of entry.)
(Name and address of consignee where inspection is to be made.)

Country and locality where grown MELLE-LEZ-GAND, BELGUIM.

Foreign shipper Achille Delaere Date of entry NOV 6 1916, 191

Number of cases 2 Marks and numbers on cases AJC 233/4

QUANTITY.	KIND OF NURSERY STOCK.
134	azaleas

MALTUS & WARE
(Name of importer or broker at port of entry.)
14 Stone Street
New York

8—6353

UNITED STATES DEPARTMENT OF AGRICULTURE,
FEDERAL HORTICULTURAL BOARD,
WASHINGTON, D. C.

D

REPORT OF FEDERAL HORTICULTURAL BOARD TO STATE INSPECTOR.

State Inspector, Indiana NOV. 9 1916

Description of Imported Stock:

The following nursery stock imported under Permit No. 528, consigned to Maltus & Ware (Name of importer or broker at port of entry.)

NY (Port of entry.), will be shipped on or about Nov. 8, 1916

to Fred Lemon, Richmond, Ind. (Name and address of consignee where inspection is to be made.)

Country and locality where grown Melle lez Gand, Belg.

Foreign shipper: Achille De Coster (Name and address.) Date of entry: Nov. 6, 1916

Number of cases and marks: 2 ADC Numbers on cases: 233/4

QUANTITY.	KIND OF NURSERY STOCK.
134	Azaleas.

State Inspector's Report:

(*Kindly report as indicated below.*)

M. E. Kimsey, (Name of inspector.) 11/22 (Date of inspection.), 1916

Certification and marking? O. K. Importer's notice? O. K. Prohibited plants? None.

Pests found and host plants 2 Exobasidium galls; a few leaf miners; Pestalozzia leaf spot common on M. Petrick

(Signed) Frank N. Wallace
State Inspector.

9—6276

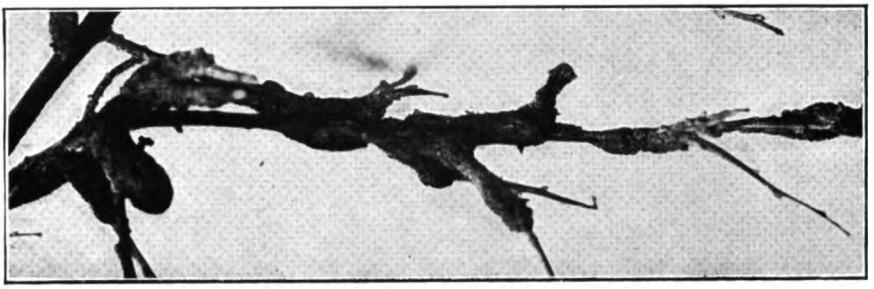
country, which now, or in the future, attemps to grow chestnut trees. In another part of this report is a record of the infestations of Chestnut Blight which were found in Indiana during the past year. These came from Pennsylvania, but Mr. J. G. Sanders, the Economic Zoologist of that state, has put a quarantine on all chestnut nursery trees, and now none can be shipped from that state. The chestnut is too valuable a nut tree to be jeopardized by permitting any state to ship diseased trees from its borders. In Indiana we have nearly a dozen nursery firms propagating the chestnut, and eventually our roadsides will be planted with this tree as well as the pecan and English walnut.

SOME RESULTS ACCOMPLISHED.

The work accomplished by the State Entomologist's office can best be realized when present conditions are compared with the conditions existing eight or ten years ago. As an example take Peach Yellows, which ten years ago threatened to destroy all the peach orchards in the State, and did kill hundreds of thousands of trees before this office started a campaign of education and eradication, causing all diseased trees to be cut down and burned. This year there were very few cases of Peach Yellows or Peach Rossette found in the State. When I sent to the county which eight years ago was considered one of the worst as far as disease was concerned, it was impossible to find a tree infested with the disease to use as a specimen at the State Fair. Some of the neighboring states still consider these diseases the most dreaded of all peach scourges, so Indiana can deem herself fortunate in having had such a thorough clean-up. We must constantly watch for symptoms of this disease, and wherever found the trees must be taken out and burned as was done before.

Black Knot of the plum and cherry is another disease which is now being eradicated. Some years ago nearly every plum orchard had this disease to a greater or less extent. The growers were instructed to cut out the branches showing the enlarged twigs, and where the tree was badly infested to cut down and burn it. This year there was not one per cent of the amount of Black Knot that was found eight or ten years ago. The growers now know what to do and whenever a branch is noticed with the swellings it is cut out and burned.

The illustration shows a badly diseased branch. This picture was taken eight years ago, but growers today do not wait until trees become in this condition before using the pruning knife. If you are not sure about any suspicious looking knots on your trees send samples to this office.



BLACK KNOT ON PLUM

Formerly the Blue Damson Plum was not planted because it seemed impossibe to grow the trees; the disease being particularly severe on this variety. Now it is again being planted, and is proving one of the profitable varieties. They are heavy bearers and the fruit does not easily rot.

PINE BLISTER RUST

This disease of the white pines attracted much attention from the men interested in forestry in states east of the Mississippi. It threatens to destroy the White Pine in the eastern states, unless prompt measures are taken to eradicate the disease. Most of the states have been slow to recognize the importance of this imported disease, and it has been allowed to gain such a foothold that it will cost millions of dollars now to eradicate it.

Some years ago Mr. B. W. Douglass, the State Entomologist at that time, discovered the disease in a nursery in southern Indiana. He had all the White Pines in that nursery burned, and asked Indiana nurserymen to stop handling White Pine until it was seen whether the disease could be held in check. This has been generally followed, and there have been very few White Pine plantings made in Indiana since that time. Last year we could find no evidence of this disease in Indiana, and it is to be hoped that we are free from it. The other host plants of the Pine Blister Rust are currants and gooseberries, and in many

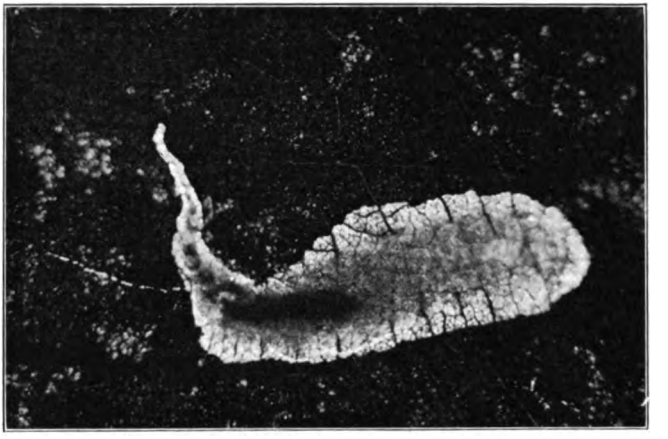
states these will be dug out and burned in districts where Pine Blister Rust is found. There is a movement on foot now to prohibit the shipment between states of all five leaved Pines, as well as all currant and gooseberry bushes. This will be done in the hopes that the spread of the disease can be checked.

Had all the states taken as prompt measures as Indiana took at that time, very little money would now need be spent eradicating this disease.

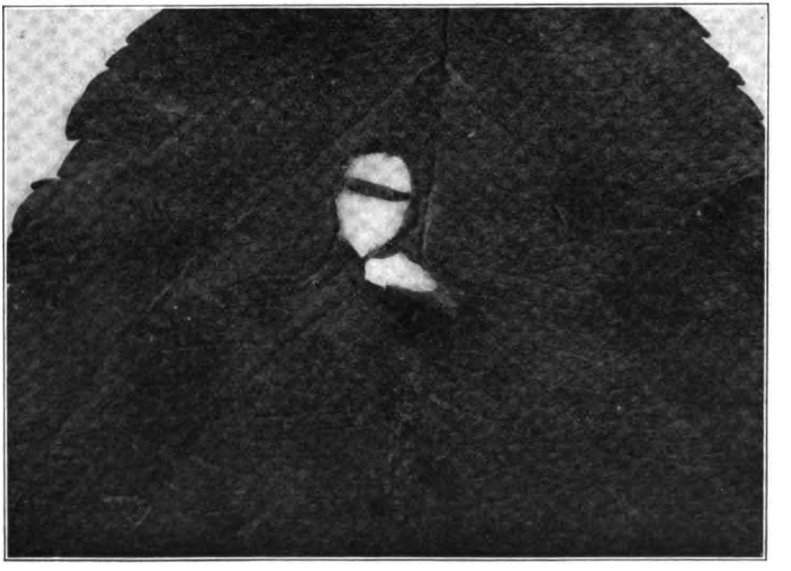
SOME INJURIOUS INSECT PESTS OF THE YEAR.

THE TRUMPET LEAF MINER

In the Eastern States this little moth does much greater damage than in Indiana. However, it should be closely watched and if its work increases the apple growers should use control methods



TRUMPET LEAF-MINER (Tischeria malifoliella-Clem.) (Enlarged about 8 X.)



TRUMPET LEAF-MINER (Tischeria malifolia-Clem.)
Skin of mine laid back, exposing larva

before it becomes a serious pest. One of the illustrations show how the mine in a leaf appears when held to the light. This photograph was taken through the leaf and shows the larva in its cell. It is enlarged about six diameters. Another picture illustrates a leaf with the skin of the mine laid back, exposing the small larva, and the other leaf shows the appearance of the mine as it will ordinarily be seen. This office will appreciate receiving reports from growers who notice this pest becoming evident or more numerous in their orchards.

There are at least two broods in Indiana, and in some parts probably three. The first are noticed in June or early July and the second in August or early September.

As the insect winters over on the fallen leaves, burning the leaves in the fall or plowing them under in the fall or spring will control this pest. It never becomes serious in orchards that are cultivated. The cultivation buries the leaves and destroys the larvæ before they emerge.

THE CLOVER MITE

This minute oval shaped mite is about one-thirtieth of an inch in length, bright brown in color with a very long pair of legs in front. In the West it is one of the serious pests in the orchards, but in Indiana we receive more complaints of it being a household pest than as a garden or orchard pest. One town reports that almost all the houses were swarming with the little pest, and that no one ever remembered of having seen them there before, or knew what to do to get rid of them. We recommended burning sulphur in the rooms that were infested. A Government bulletin states that oil of pennyroyal placed in shallow dishes is very effective in driving the insects out of the houses, but we have not tried this method. Usually complaints do not come in until late fall or early winter.

THE PEACH TREE BORER

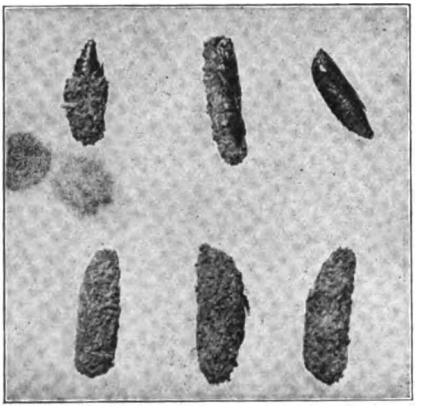
This is a native insect and causes more loss to the peach growers than even the San Jose scale. So far, no easy, sure method has been devised, whereby the tree can be protected from its attacks. The only unfailing method is the old back-breaking one of digging them out with a knife, and there is nothing in fruit growing which is so dreaded by the growers as "worming" peach trees. Experiment work has been carried on with Carbon Di

Sulphide and it is believed that this method will soon replace the old knife method, but until more work has been done along this line the growers will have to still break their backs digging them out. Trees should be examined thoroughly as late in the fall as practical and again in May or early June. The full grown

Young peach tree showing larva of peach tree borer and damage done to the base of the tree

larva is light yellow with a brown head and nearly an inch long. The soil should be removed for a depth of five or six inches and the wax around the trunk will show where the borers have been working. Sometimes it will require considerable cutting into

the bark to find the borer, but less damage will be done by the knife than if the borer were allowed to remain. After the men are sure they have all been dug out, the soil should be mounded up eight or ten inches high around the trunk. The moths lay the eggs near the surface of the ground and this mounding forces the moths to place the eggs higher up, and prevents the young borers from going as deep down on the trunk as they usually do. It also makes it much easier to dig out the next crop of borers, as the one doing the work can easily remove the soil which was mounded up around the trunk. Do not stop when one borer is found. Fifteen to twenty are often found in one tree and they should all be removed. Also, all old neglected trees should be cut



Pupae cases of peach borer. These can be found around the base of the trees infested with borers

down and no seedling trees allowed to grow along the roadsides and in neglected places. One moth can lay from two hundred to six hundred eggs, so it is apparent what damage can be done by having a neglected orchard in your vicinity. Do not neglect your own orchard or it will become a menace to your neighbors, who are caring for theirs.

In the summer if you notice some of the trees turning yellow and the leaves dropping, it will nearly always prove to be from an attack of borers. Some have been missed when the trees were gone over in the spring, and it will be advisable to go over these which do not have a healthful appearance. Some of the borers may be working down on the roots, and the soil should be removed down a foot or more and the roots examined. I have had growers

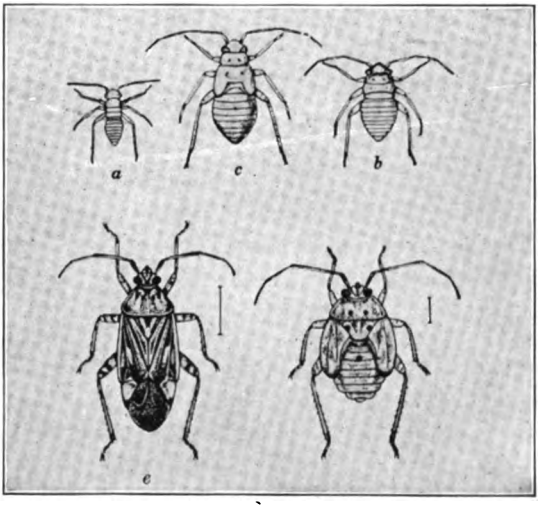
insist that it could not be borers that were troubling their trees, as they had done the work themselves, but usually I could find some of them down on the roots doing the damage.

The borers leave their burrows sometime during the summer and make a pupæ cases as shown in the illustration, often remaining in this case from three to four weeks. They emerge as beautiful clear wing moths, which are frequently mistaken for wasps. The moths emerge from the middle of June until the last of August. They do not have any special time as most moths do, and hot or cold seasons apparently do not make any difference in the time of their transformation.

Often great numbers of small white wire worms are found in the wax surrounding the borers, and these are often mistaken for young borers. They do no damage to the trees, and are only there to feed upon the wax, and no attention need be paid to them.

TARNISHED PLANT BUG

This active little bug was very noticeable during the past season, and is one of our most troublesome insect pests. This pest will attack almost any plant, while most of the others confine their attacks to plants of one family. The Tarnished Plant bug caused much damage to the flowers and garden vegetables in the cities as well as in the country, and is one of the most difficult to control. The farmer can better control it as the insect winters as an adult, hibernating under boards, trash or brush heaps. By cleaning up and burning all trash most of the insects will be destroyed. The city man with a small garden must necessarily have many places in which the insects can winter over. The



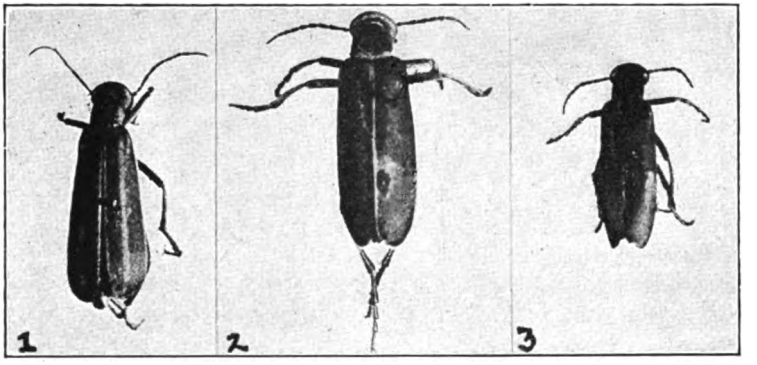
TARNISHED PLANT BUG LIFE HISTORY
(after Forbes & Chittenden U. S. D. A.)

young or nymphs can be killed by spraying with a solution of nicotine sulphate one teaspoonful to a quart of water. This must be sprayed directly upon the insect. It is a sucking insect, as are all the true bugs, and an arsenical will not poison them; a contact insecticide must be used.

BLISTER BEETLES

These were not reported as frequently this year as formerly, but this might not be due to their scarcity so much as that of the Aster, of which they are particularly fond, and which was a failure in Indiana this year.

The Black Blister Beetle (Epicanta Vettata), often called

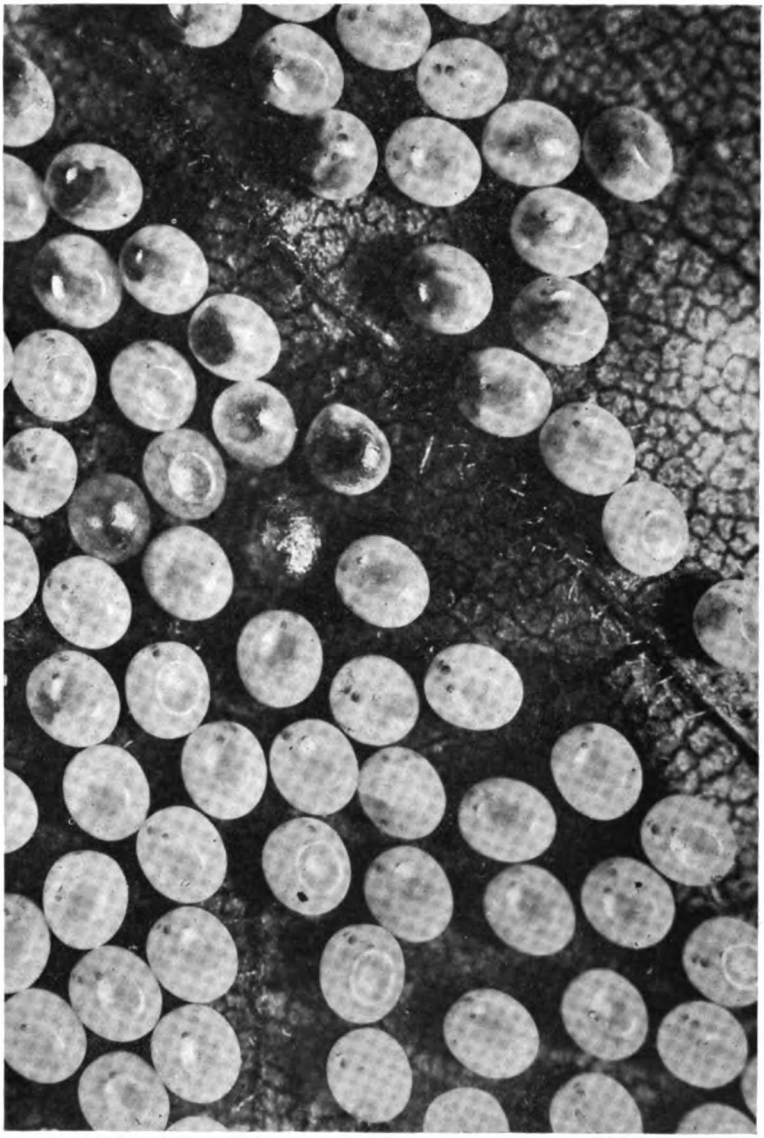


BLISTER BEETLES

"The old fashioned potato beetle" is the one the gardener is troubled with most, although there are several which cause him much loss. They can be poisoned by the use of arsenate of lead, used one pound of powdered to twenty-five gallons of water, or it can be dusted on the plants dry.

These beetles, after a season that the grasshoppers have been bad, are much more numerous, and we can expect to see great numbers of them during the season of 1917. In one way they are a blessing, as the young larvæ feed on the grasshopper eggs, thus causing that pest to be held in check.

Their life history is very interesting. The females lay five or six hundred eggs in a small cavity in the earth sometime between July and October. In about ten days these hatch into small very active larvæ with large heads and long legs. They start in search of the egg masses of the grasshoppers, which are



EGG MASS OF CATALPA SPHINX GREATLY ENLARGED.

likewise laid in the earth. The young larvæ of the beetle feed on nothing but these egg masses, and when found they eat a full meal and then shed their skins. At this time they have short legs and are very sluggish, and the pod-like mass of grasshopper eggs is sufficient to feed them till maturity. After another moult, and all the eggs are consumed, the larvæ go deeper into the soil and shed thier skins and winter over in a semi pupæ stage. In the spring the larvæ soon go into the pupæ stage, from which the adult beetles appear later.

CATALPA SPHINX

For years the larvæ of this moth have defoliated most of the catalpa plantations of the state. This year they seemed particularly severe on the catalpa trees in the cities and towns. The office received more requests for information about this pest than ever before. Several years ago we believed that the parasites which work on the larvæ would control it. This year in some cases it was almost impossible to find a larva which was not parasitized. It may be that this pest will be checked within the next few years by this means.

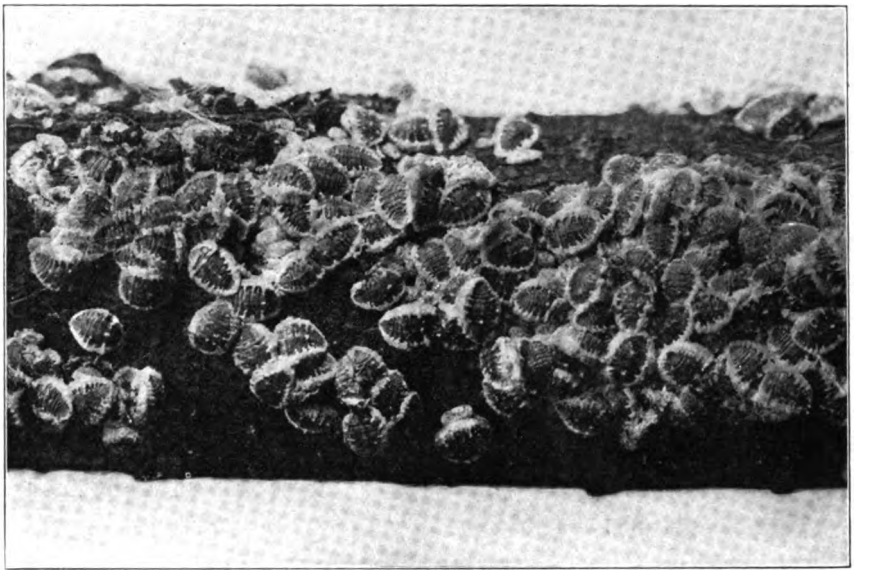
For the city man with a few trees we recommended spraying with arsenate of lead three pounds to fifty gallons of water as soon as the small larvæ show on the leaves. Do it as soon as the first evidence of their work is noticed, as they are voracious feeders and in a few days may defoliate your tree. If eggs are noticed on the leaves pull these and burn them. The cut will show the arrangement of the eggs upon the leaf, although the picture is greatly enlarged.

We have had possibly one hundred or more requests for information in regard to this one pest during the year from people living in Indianapolis.

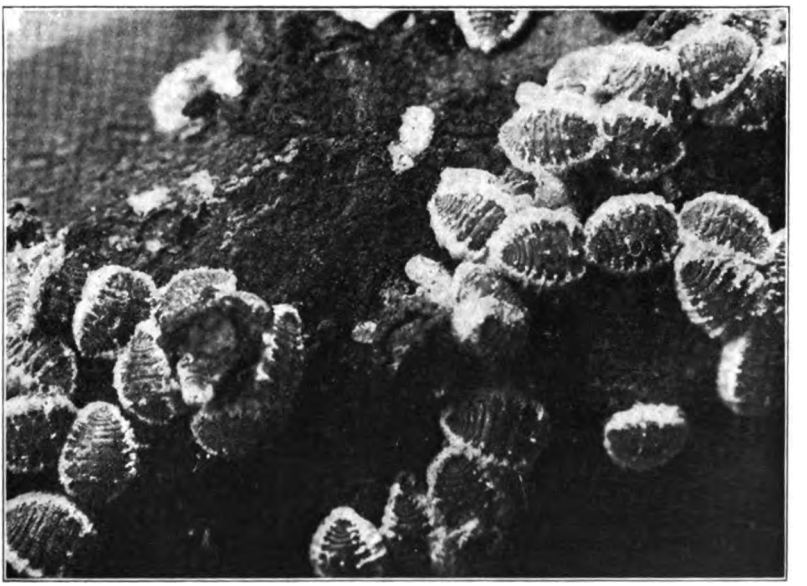
EUROPEAN ELM SCALE

The office was asked to send an inspector to the ground of the Central Hospital for the Insane at Indianapolis, to identify a scale which Mr. O. Thompson found troubling the elms on their grounds. This proved to be the European Elm Scale, which had been discovered once before in Indiana, and then only upon a few trees in a nursery. At the hospital grounds it was found to have spread over most of the elms there, and also to have extended to the elms adjoining their place.

Experiments with various materials at varying strength proved that scalecide used one part to fifteen parts of water was the only effective solution, and during the coming spring efforts



EUROPEAN ELM SCALE (Slightly Enlarged)



EUROPEAN ELM SCALE (Greatly Enlarged)

will be made to exterminate this pest. Mr. J. H. Lowry, the Superintendent of Parks in Indianapolis, has promised the co-operation of the Park Board in this work. It would be a serious situation if this scale were allowed to spread to the elms of the city. The only thing to do is to absolutely eradicate it in its now limited location, and see that no more elms are planted near there until we are sure that it has been exterminated.

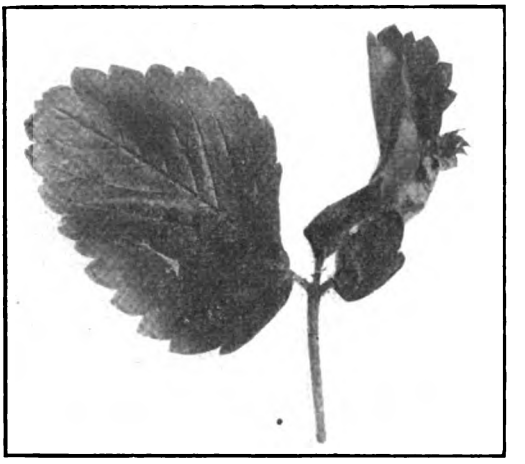
The badly infested trees will be cut down and the remainder of them thoroughly sprayed and watched next summer to see that the work has been effectually done. The photographs show clearly the appearance of this scale, and we ask that samples be sent to the office, should you notice anything upon elms which would lead you to believe that this pest is in your locality.

There has been no other pest in the State which would cause more damage to our elms than this one.

The condition at the hospital grounds will present a situation which will show whether prompt measures for eradication of insect pests will give results. If this scale insect spreads to the elms in the city parks, it will endanger the lives of the elms upon which the Park Board has spent years of effort and much money in bringing to their present size and beauty.

STRAWBERRY LEAF ROLLER

This pest was found in nearly all strawberry fields examined the past year. Some fields had only a light infestation, while others had as high as fifty per cent of the plants infested.



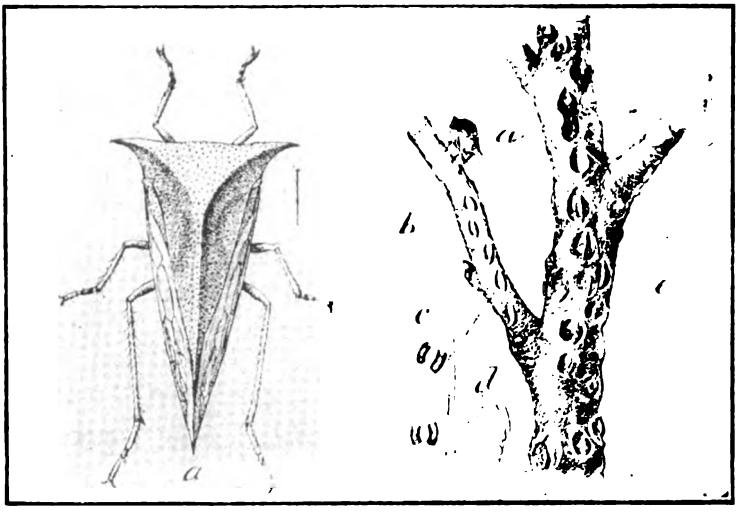
STRAWBERRY LEAF ROLLER

These insects are moths measuring slightly less than one-half inch across the expanded wings. They fly during the day, but hide under the leaves when disturbed, so that they are seldom noticed close at hand.

The young larvæ hatch early in May in Indiana, and in spraying to control this pest the work must be done before the larvæ appear. The young larvæ eat along the mid rib of the leaves and in two or three days start drawing the edges of the leaf together, and after this takes place they are out of the reach of a poison spray. A pound and a half of powdered arsenate of lead to each fifty gallons of water will control this pest, if two to three sprayings are given a week or ten days apart. The adult moths lay eggs for a period of about thirty days, and three sprayings will be certain to cover the egg laying period. In fields which are badly infested, as soon as the berries are picked, mow the plants and burn over the field. This will lessen the number of moths for later broods, and thus help conditions the following year.

BUFFALO TREE HOPPER

During the past season we have received many samples of twigs, damaged by this insect in depositing her eggs. The bark



BUFFALO TREE HOPPER AND INJURY

on the small twigs is cut in an angular shape about one-eighth of an inch long and the eggs laid under the cut skin of the bark. Some of the samples showed most of the twig surface covered with these cuts, and many of the growers imagined that some strange fungus disease had started in their orchards. The adult

is an odd looking green insect about three eights of an inch long. The head is broad and expands on the sides into two horns, which give it slightly the appearance of a minature buffalo, hence the name, Buffalo tree hopper.

They are seldom serious in well cared for orchards, and when the egg punctures are found the trees should be given a rather severe pruning and all the twigs gathered and burned. The burning of the prunings should not be neglected, as this pest has become quite serious in some states, and Indiana growers can control this pest now with little work and care. Keep the orchards free from weeds, and weed patches near the orchards should be cut in midsummer, especially in August. Egg laying usually begins in August and is continued some seasons until frost.

IF YOU ARE NOT SURE ABOUT THE EGG PUNCTURES OF THIS PEST, SEND SAMPLES TO OUR OFFICE, ROOM 130, IN THE STATE HOUSE AND WE WILL ANSWER IMMEDIATELY.

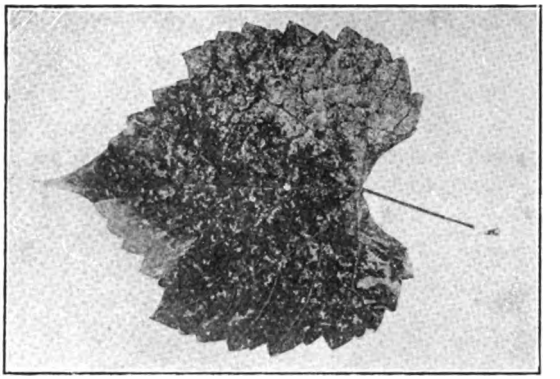
GRAPE LEAF HOPPER

Many requests were received for advice on the control of this pest of the grape during 1916, but the damage had progressed so far that very little could be done to save the crop. They are beautiful little insects one-eighth of an inch long with red and yellow markings. There are several different varieties, but are all classed under one head and all look much alike.

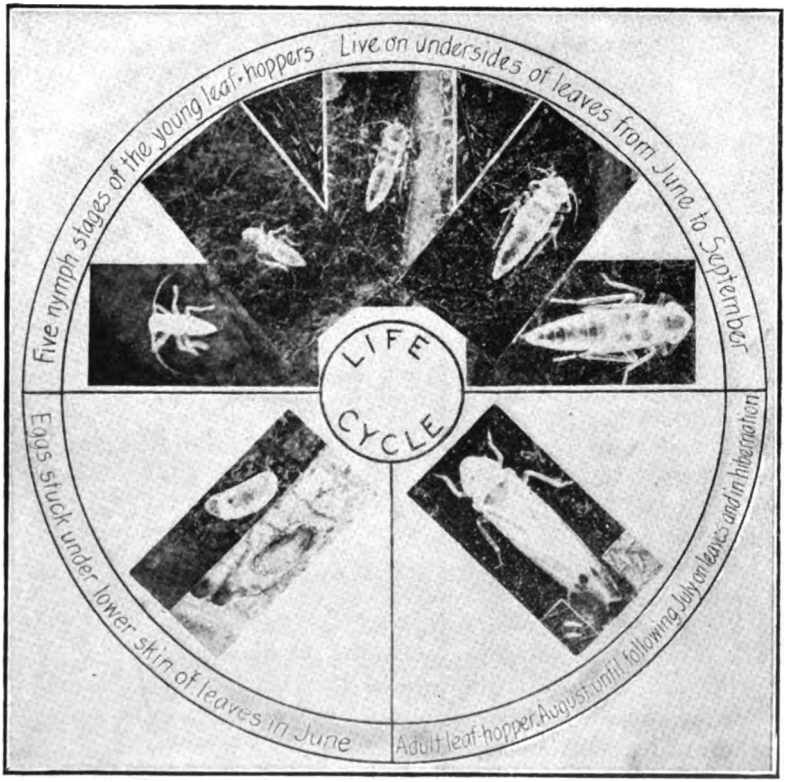
They winter over as an adult insect under trash and in fence rows, and even under the fallen grape leaves.

Cleaning up around the vines and burning all trash and leaves helps greatly in the control of this pest. Burning over the garden patches or weed patches near the vineyard also kills many of the insects.

If the young show on the leaves in the spring, nicotine sulphate can be used as a spray and will kill any of the nymphs touched by it. This can be added to the bordeaux, arsenate of lead spray, used to control the grape diseases and Grape Berry Moth.

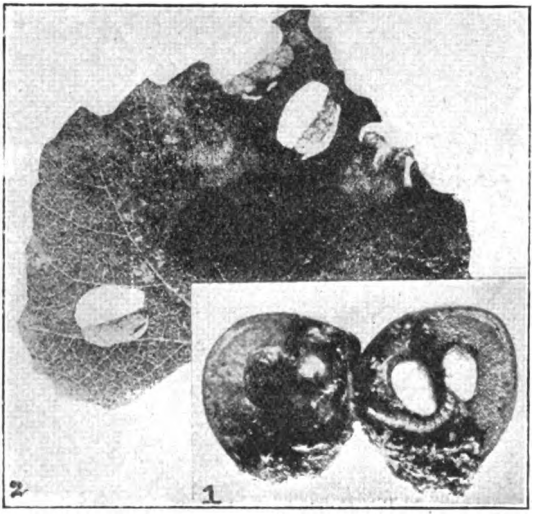


GRAPE LEAF HOPPER INJURY



GRAPE BERRY MOTH

During 1916 this moth caused great loss to grape growers in Indiana. Very few vineyards raised perfect grapes, except where they were sacked early in the season. Even where vines were sprayed some damage was done, although spraying with one and



GRAPE BERRY MOTH
Fig. 1 Larva Fig. 2 Cocoons
(after Slingerland)

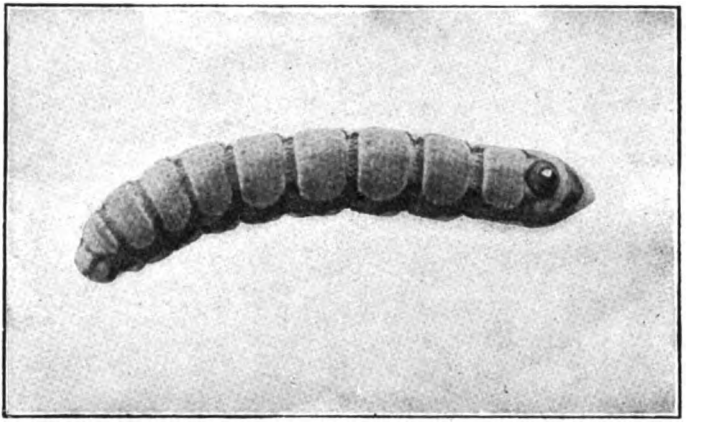
one-half pounds of arsenate of lead to fifty gallons of water will usually be found effective against this pest. There are two full broods, and some seasons three, especially in the southern part of the State.

GRAPE CURCULIO

This pest does not cause as much damage as the Grape Berry Moth, however, in some seasons the loss is quite severe. The spraying for the moth will control this pest also, as the adult beetles feed on the leaves early in the season, and will be poisoned by the arsenate of lead spray.

GRAPE SPHINX

There are several Sphinx Moths which feed on the foliage and many of the larvæ are sent in by mail, or brought into the



GRAPE SPINX LARVAE

office for identification. They seldom become numerous enough in Indiana to be of any great economic importance.

GRAPE PHYLLOXERA

Leaves from infested vines are sometimes sent in to the office for indentification. It is usually found on wild vines, and seldom ever causes any damage to cultivated varieties in Indiana. People sending in specimens usually are fearful of this pest spreading to the home vineyards.

CURRANT APHIS

The foliage of currants, and frequently gooseberries, are found curled and twisted in the spring. Sometimes the young leaves show discoloration, being quite red. On the under side of the leaves will be found the plant lice.

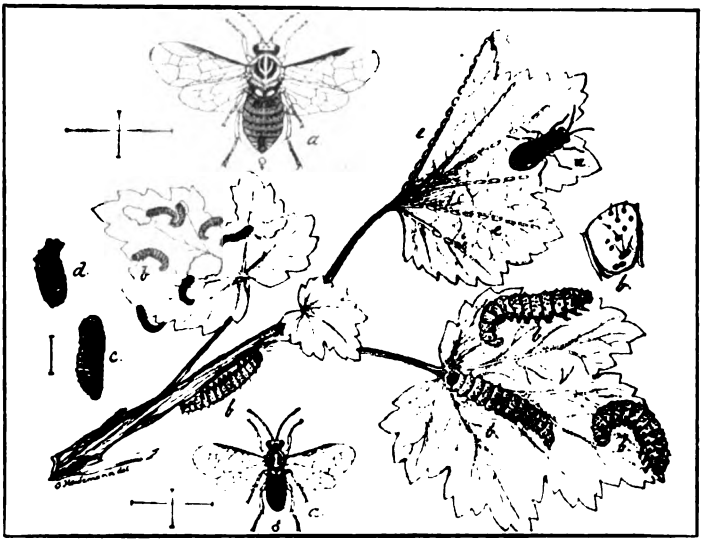
Spraying with kerosene emulsion or nicotine sulphate will control this pest if the leaves do not become too curled for the spray material to strike the insects. All contact insecticides must touch the insects or they will not be killed. Hence the spray must be applied as soon as the pests are noticed.

In very small patches in the garden the leaves showing the aphids can be gathered and burned. This is only practical where there are a few bushes for home use.

The eggs of the aphids can be seen along the stalks of the plants, and when present can usually be killed in winter or early spring by an application of one gallon of lime-sulphur to five gallons of water.

IMPORTED CURRANT WORM

This pest probably does more damage to the currants and gooseberries than all the rest of the pests, with the possible exception of the San Jose scale.



LIFE HISTORY OF CURRANT WORM

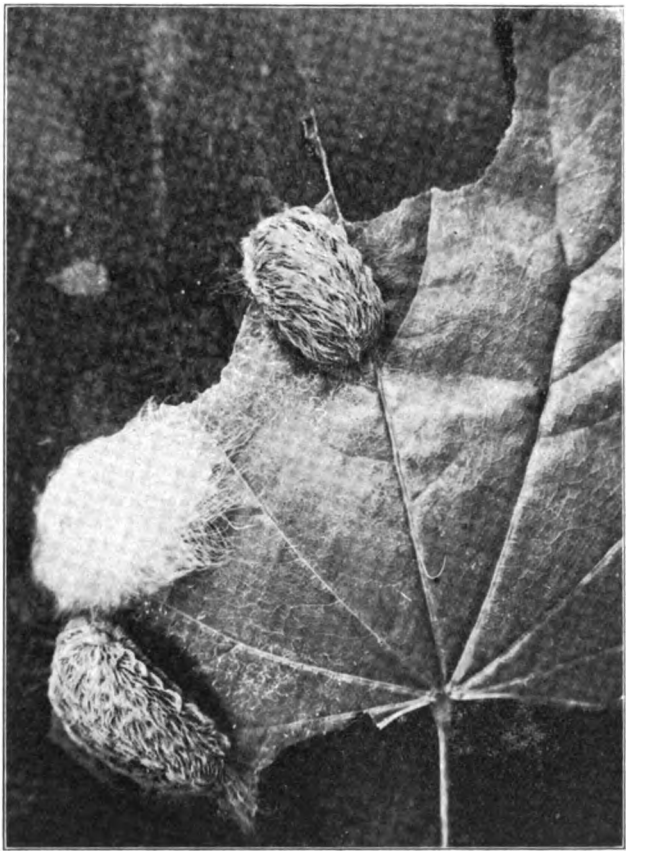
It is a saw fly and lays its eggs along the ribs of the leaves. These hatch in about five days and the small larvæ at first skeletonize the leaves, and a little later eat the entire leaf. They develop rapidly and often the grower notices no damage until his bushes are defoliated.

This weakens the bushes and they cannot produce much fruit after the leaves are gone. There are two broods a year, and frequently the bushes lose a second set of leaves late in the summer. Arsenate of lead applied just after the bloom has fallen will

effectually control the young larvæ, and no injury will be done to the fruit. It should not be applied just before the fruit is ripening, as the poison would show on the fruit at the time of picking.

FLANNEL MOTH

The Yellow Flannel Moth (Lagoa crispata) was found feeding on sassafras June 2, 1916. The larvæ were brought to the



FLANNEL MOTH (Lagoa Crispata-Packard.)

office and two reared to adults to be sure our identification was correct.

The larvæ are nearly an inch in length and more than one-half inch across the center. At the time they were collected

some were pure white, but most of them were a light brown, and all were covered with long silky hairs. The white larvæ moulted, changing to a light brown. Evidently all the larvæ were white in the early stages. The single white larva, here shown, moulted the day this photograph was taken and emerged as shown. Interspersed among the long hairs which cover the larvæ are shorter stiff spines which are hollow, and these contain a poison which is very irritating, especially to a tender skin. A touch on the hand or arm usually causes the whole arm to ache and the soreness remains for twelve to fourteen hours.

This pest was evidently brought to Indiana on some experimental plants, which were shipped from Washington, D. C. to Mr. Benj. W. Douglass, as the pest has never been reported here before, but is known in the Eastern states. Mr. Douglass' place will be examined carefully during the coming season to see if any larvæ were missed last year. If they are found we will endeavor to thoroughly eradicate them.

TREE GUARDS

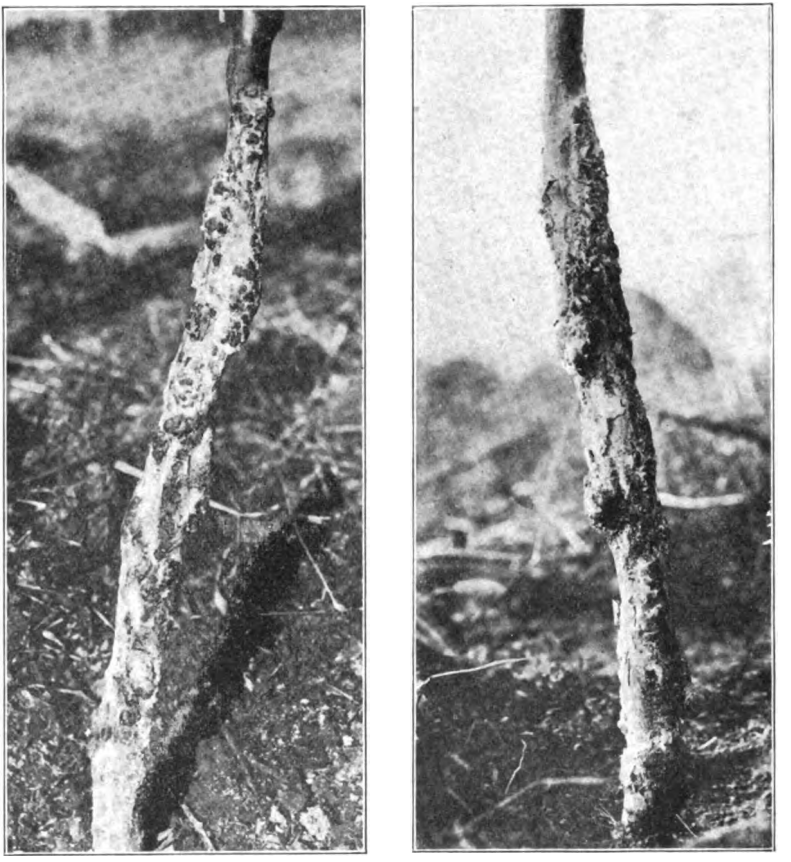
Young apple trees need protection from rabbits during the winter season. Just what protection should be given is often a difficult problem to decide to the man who is setting out a new orchard. There are so many methods in use, and each seems to have certain advantages, and often the orchardist cannot make a decision before the rabbits do serious damage to his trees. I much

Young apple girdled and killed by mice. Grass should be removed from base of the tree before winter

prefer the woven wire tree guard. After it is put on it can remain there until after the trees are old enough to be comparatively free from danger from the rabbits. The initial cost is greater than the other methods, but if the saving of time for five or six years is considered they usually are cheaper in the end.

Many growers use a paper wrapper, but this sometimes gets

torn from the trees. Mice often gnaw it away at the base of the trees for nests. It must be removed in the spring as it makes a splendid harboring place for insects. The illustrations show two trees which were badly damaged by woolly aphids and there were many trees in the orchard in as bad a condition as these two.



WOOLLY APHIS DAMAGE ON YOUNG TREES WHICH WERE WRAPPED WITH PAPER IN THE FALL AND ALLOWED TO STAY ON ALL THE NEXT SUMMER

The wrappers were allowed to stay on nearly all summer as the owner did not live on his place but had a man to care for it. These trees have this season received excellent care and very little of the damage can now be seen on the trunks of the trees which are now two years old. If you should use paper wrappers do not fail to take them off in the spring.

One grower near Peru used a much advertised tree paint which was guaranteed not to injure the trees and he lost his entire orchard with the exception of one row which in some manner was missed when the trees were painted. Do not use a paint to keep rabbits away as the paint is often more injurious than the rabbits.

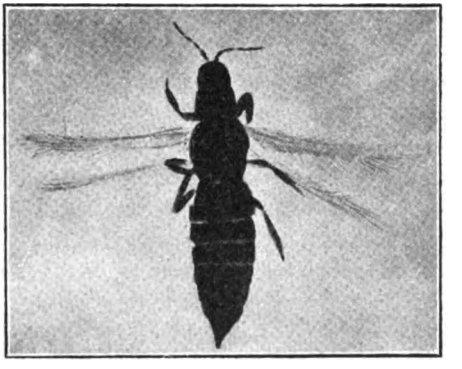
There are veneer wrappers on the market and these are easy to apply but usually can only be used one season thus incurring an annual expense. Like the paper wrapper they must be removed in the spring as the insects like the protection and the trees are nearly always damaged if they are not removed in the spring.

ONION THRIPS

M. E. KINSEY

THRIPS TABACO

This insect has been very bad in Indiana for the past few years, especially in localities where onions have been grown commercially for some time. Stark county has known the pest for



ONION THRIPS (Adult)

a number of years and Steuben county experienced an outbreak in 1914, which did great damage, not only to the year's crop but in the fact that very many growers were discouraged by the failure.

The young nymph usually makes its appearance about the time the onions have attained four to eight inches growth, and it

is at this time that the damage is done. The insect is so small that great numbers of them are hatched before they are noticed; the characteristic wilting of the tops calling attention first to their presence. The leaves whiten and die prematurely, the appearance of the tops giving rise to the names "White blast", "White blight", and "Silver tips" to the trouble. (A badly infested field presents a very discouraging appearance, but in many instances if thoroughly sprayed will recover to quite an extent.)

As soon as the onions are through the ground close inspection should be maintained for the thrips. The nymphs or immature insects congregate in masses at the base of the leaves. By pulling the leaves apart the thrips will appear as minute yellow elongate specks resembling particles of corn meal.

On account of the small size of the insect a study of the life history is almost impossible. However, the life history as stated below is generally regarded by most authorities as probably true.

The parent insect, supposedly, winters over in the rubbish and old tops on the ground. Egg laying commences as soon as the females appear, which is in the spring or early summer. A slit is cut in the epidermis by means of a saw-like organ at the end of the abdomen, and the egg is placed just underneath the surface. This egg hatches in a few days into the immature thrips or nymph. Feeding is commenced at once, first by rasping off the epidermis of the leaf and then by sucking the plant juice. After a few days of voracious feeding the nymph becomes too large for its skin. The skin is then cast and a new one formed underneath, which gives the insect room to grow. This process is called molting. Several molts are passed through before the insect reaches the mature stage. The adult insect is very small, being only about one-twentieth of an inch long. The body is slender and elongate, having two pairs of bristly narrow wings, which have no use in flight. The wings when at rest fold along the back.

When full grown the females commence to lay eggs for the next generation, and as the life cycle—period from egg to adult—is only three weeks, several generations may be produced in a year.

A contact spray is used in the control of the thrips and must be applied at intervals of not over three weeks until the pest has been controlled or the onions are large enough to be out of danger. Considerable pressure must be used in order to force the

liquid down into the junction of the leaves where the thrips collect. A forty per cent nicotine sulphate solution is the material that has given best results, and the formula is as follows:

Nicotine sulphate	4.3 ounces.
Whale oil soap	4 pounds.
Water	50 gallons.

The first thing that is necessary is a pump that is both efficient and practical. Many different arrangements have been tried in which power machinery was used to distribute the liquid, but the heavy outfit is not only hard to haul around over the soft onion ground but roads must be left through the fields for it and much ground is wasted. With such an outfit the long hose must either be carried on a long boom anchored to the sprayer or carried by men to keep it from dragging down the onions.

The following description is of a machine constructed by the writer in trying to overcome these obstacles, and while not the best that could probably be made, worked very successfully.

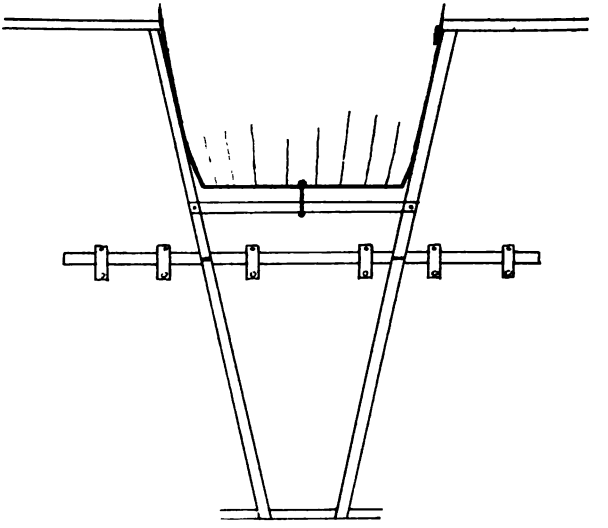


Fig. 1.

The drawing will show without much explanation the machine construction. A side barrel pump was used and the pump turned so the handle was lengthwise of the barrel. A set of old wheels as well as an axle was picked up out of an old junk heap. The axle was bent in a yoke to receive the barrel and allow about one foot clearance. One end of the axle was left long enough to

allow adjustment to the rows and a number of holes drilled for the keys. The barrel was placed in the yoke slightly forward of

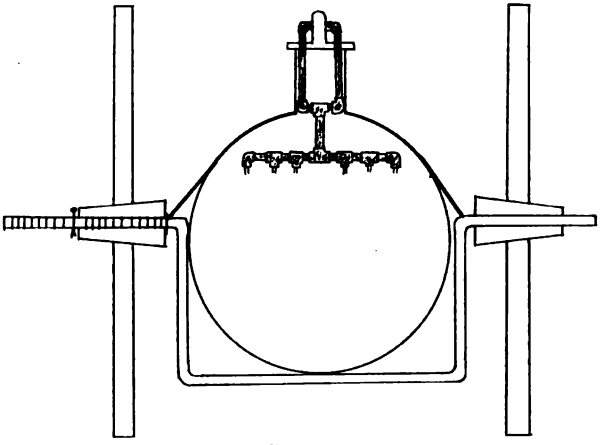


Fig. 2.

center so that the weight might tend to over balance the action of pumping. The barrel was then fastened by a strap over the top and fixed to the yoke on either side. The tongue was put in so the two pieces would touch the barrel on the sides and help support the weight, and a cross piece was bolted to the barrel head and then to the tongue, making the barrel solid on the truck.

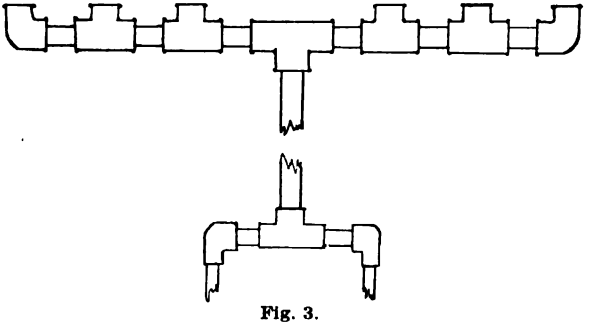


Fig. 3.

In figure 3 the distributor is shown composed of six ½ inch nipples; six ½ inch T's; two ½ inch elbows; six ½ to ¼ inch reducers to which the feed lines to the nozzles were attached; twelve pieces of ⅜ inch gas pipe about four inches long. The length of feed pipes to the distributor as well as the feed lines to the nozzles will have to be determined after the distributor is fastened to the barrel. Feed lines to nozzles should be long

enough to allow of considerable adjustment of nozzles. Feed lines to distributor should be of ¾ inch pipe and should be attached to the two hose connections on the pump. Feed lines to the nozzle were ⅜ inch hose. The pieces of ⅜ inch gas pipe were used in each end of the hose and the nozzles. The nozzles were attached at one end and the other end screwed into the reducers on the distributor.

A six foot half inch pipe was attached to the tongue so as to be adjustable for height and the nozzle strung on the pipe by

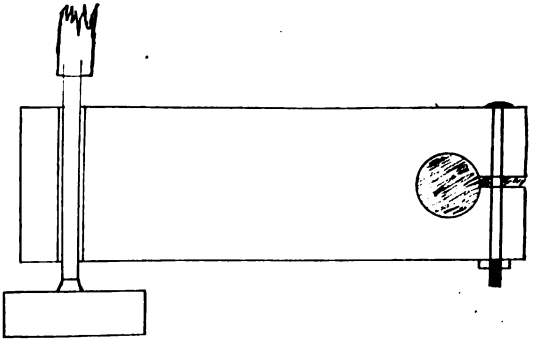


Fig. 4.

means of wooden clamps (Fig. 4). A half inch hole is bored in one end of a 2x2x4 inch block. A sliver of wood was then sawed in the end of the block parallel with the half inch hole. A bolt tightened up across this split then made a clamp. A three eighths inch hole was drilled in the other end of the block so that the nozzles would point downward.

After adjustment the machine was ready for work, and it was found that sufficient pressure was available for supplying the six nozzles with good pressure.

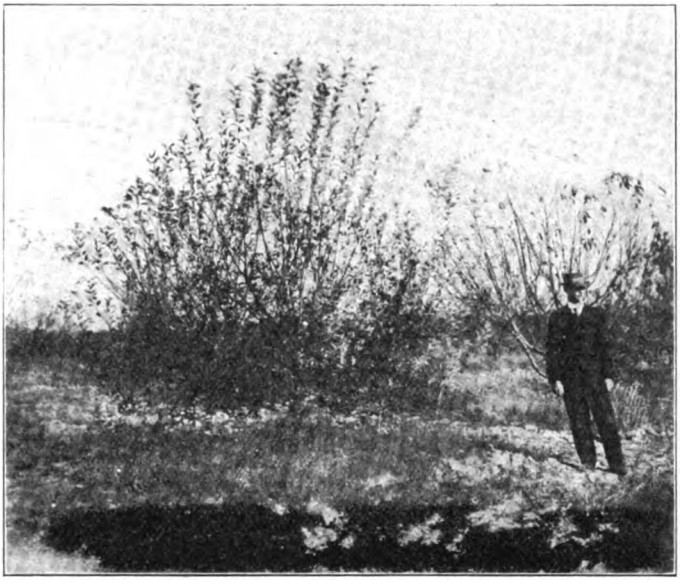
PRUNING THE ORCHARD

The inspection work carried on by the State Entomologist's office gives us much opportunity to compare the many systems of pruning which are in use in this State. It has also given us an opportunity of seeing the effect of some of those systems when systematically carried on since the time the trees were planted. In this State either the open head system or the central leader system can be used, and it is doubtful if either can be said to

THESE TREES WERE PLANTED TOO CLOSE AND TOO MANY LIMBS WERE ALLOWED TO GROW. START YOUR TREES RIGHT

possess the greater advantage. If the grower decides upon one system and carries that out he will have success, but some one system must be decided on and that carried out. The young trees cannot be allowed to grow rank the first three or four years and then put in shape. If growers will examine some old orchards and carefully note the number of main branches on well formed trees they will seldom find more than four. Most well formed trees have three main branches. Some have a center leader and some do not. This is a matter for the grower to decide upon. I see many young orchards with six, eight or as many as ten

branches growing within a space of two feet, but half of these branches will need to be removed before the trees are ten years older and then the trees will not be so strong or as well balanced as they would be if they had been put in good shape the first few years.



SIX YEAR OLD TREES ON THE ALBERT E. COTTY ORCHARD IN BROWN COUNTY

There is a tendency among some new orchardists to let the trees grow rank for the first four or five years, believing that by so doing the tree will be sturdier and come into bearing earlier. The tree may bear earlier—I doubt it—but it certainly will not be sturdier. This system originated by a few men who claimed that that their trees were never pruned. What they did do was to pinch off the young shoots they did not want and only allow the ones wanted as permanent branches to grow. This necessitated going over the orchard many times during the growing season, which the ordinary grower does not do. With this system it is not necessary to prune the trees during the dormant season, but the trees are pruned and the growers who wish to follow this method should remember that it means spending much time in the orchard when the growth first begins in the spring.

The tree shown is in Mr. A. E. Cotty's orchard near Fruit-

SIX YEAR OLD TREE IN DR. MASON'S ORCHARD

SAME TREE TWELVE YEARS OLD IN DR. MASON'S ORCHARD

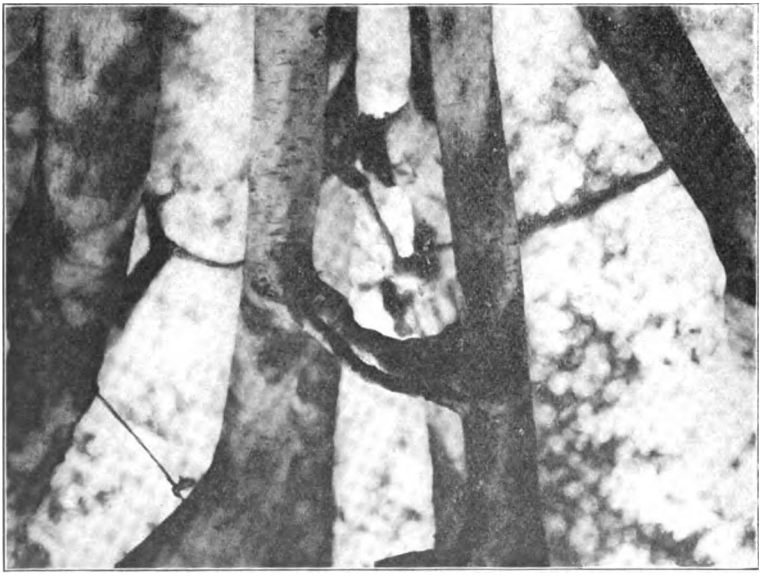
dale and illustrates a well formed tree five years old. Mr. Cotty started with the idea of having three main branches and a leader and has kept this plan and allowed very little surplus wood to grow. The result shows a tree which most growers would be proud of at seven or eight years. These trees will bear as early as the ones permitted to grow "naturally" and will be producing much heavier crops. His four year old peach trees produced nearly enough peaches to pay his entire running expenses that year.

During the summer of 1910 Mr. Benj. W. Douglass, former State Entomologist published in his annual report a picture of an eight year old Jonathan tree in Dr. G. C. Mason's orchard, situated near Oakland City. While on a trip through that part of the State this summer I visited this orchard in company with Dr. Mason and took another photograph of the same tree. Both pictures are here shown and the remarkable growth of this tree during the past six years can easily be seen. This is an ideal orchard and the results accomplished by Dr. Mason should be an incentive to others who are now starting, or have started orchards.

Before Dr. Mason planted his orchard he had an ideal tree in mind and each year pruned his orchard to conform as nearly as possible to that ideal. He never changed his mind as to what an apple tree should be, and today his trees are as nearly perfect in form as any grower could expect.

One row of trees in this orchard has always been damaged by Apple Blotch, and the cut shows how nearly these trees were defoliated by this disease. If they cannot be kept free from Blotch by a winter spray with strong lime sulphur solution applied the coming spring he intends to cut down this row. They are a continual source of infection to the neighboring trees, although so far he has been able to keep the fruit free from blotch on all other varieties.

Apple trees nearly killed by apple blotch in Dr. G. C. Mason's orchard near Oakland City. This is in an orchard which has been sprayed every year and the other trees are free from blotch



A good tree brace. Where a tree has been allowed to develop a bad crotch and there is danger of the tree splitting, small branches can be twisted around each other so they will unite and form a living brace

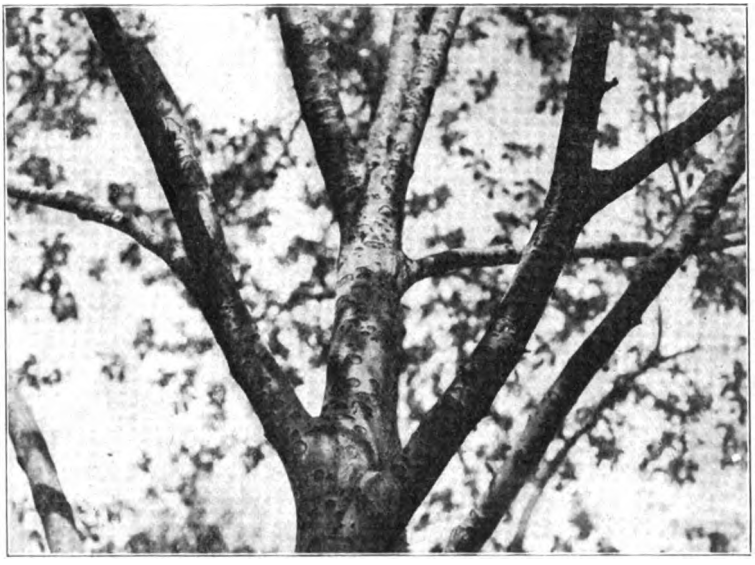
SIMPLIFIED DIRECTIONS FOR SPRAYING

There was incorporated in the Eighth Annual report of the State Entomologist a complete spray calendar, and several thousand were published as separates. Part of these are still available and any resident of Indiana may secure one upon application to this office. Many of the Ninth Reports will go to residents who do not now have the Eighth, and it has been deemed advisable to incorporate in this volume directions for spraying in the plainest, most concise form possible. If there is any point upon which the reader may want more minute directions, the information will gladly be furnished by this office.

As apple growing in Indiana is now receiving more attention and advertising than any other fruit, it will be taken up first.

THE DORMANT OR WINTER SPRAY

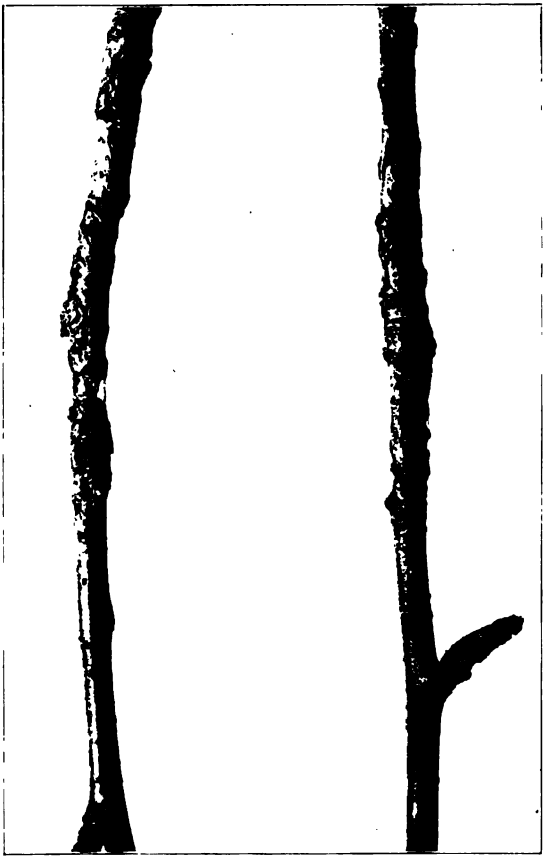
The San Jose scale first made this spray a necessity in Indiana. Since using it for that purpose the growers have found it such



Hail injury on trunk and branches of apple tree. This injury is often mistaken for a fungus disease

a benefit to the trees in helping control fungus diseases that it is now considered one of the important, if not the most important, of all sprays. I have been experimenting upon the

control of apple blotch by an application of strong lime sulphur solution, and have had remarkable results. It seems probable that this disease, which costs Indiana growers as much as any other apple disease, will eventually be controlled by winter spraying.



APPLE BLOTCH CANKERS

On young twigs of apple. The disease winters over in these cankers

Results will be watched closely again during 1917, and this office would appreciate hearing from those who use strong lime sulphur solution for the control of apple blotch, whether they get results or not. To be effective the solution must be used not weaker than one gallon of lime sulphur solution to five gallons of water. One gallon to four gallons of water is even better. The trees must be

thoroughly covered, absolutely drenched. The loose bark of the cankers must be allowed to soak up all the solution possible.

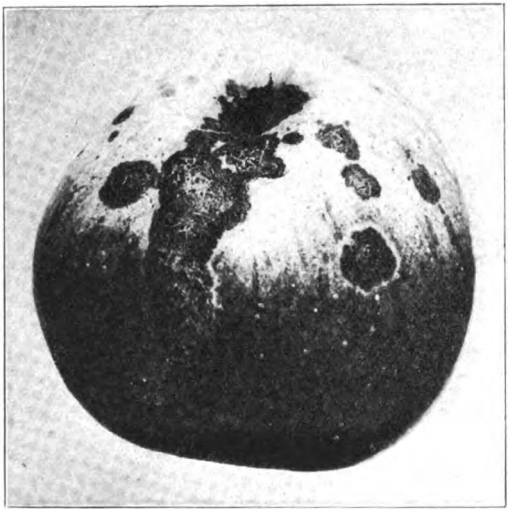
OYSTER SHELL SCALE ON PEONY

A tree so sprayed will not have many scales left alive to breed and multiply the following summer, and there will be few fungus spores found starting infections the next summer.

FIRST SUMMER SPRAY

This spray must be applied before the flower buds open, and the most effective time is while the pink color is just starting to show in the cluster of blooms. At this period each flower is separating from the cluster and the solution can cover each bloom and stem.

Use one and one-fourth gallons of 32% lime sulphur solution to each fifty gallons of water and add three pounds of paste arsenate of lead or one and one-half pounds of the powdered form. If plant lice (little dark green bugs) are found on the opening buds, nicotine sulphate should be added at the rate of one part of nicotine to eight hundred parts of water; in other words one-half pint to each fifty gallons of solution.



APPLE SCAB

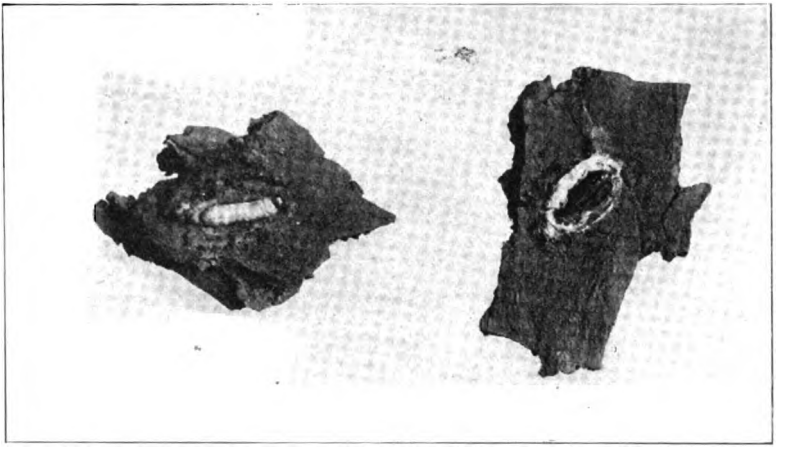
This spray controls the apple scab fungus, which is so dreaded in some sections and which often destroys the promise of a crop by attacking the tender stems of the blossoms. An apple bloom with a trace of apple scab on the stem cannot secure enough nourishment through the stem to mature an apple, and even though the fruit apparently sets it will drop before the apple gets much larger than one-half inch in diameter. This condition often occurs, and the blame usually attributed to spring frosts. In well cared for orchards on rolling ground in Indiana very little damage is done by frosts to apple orchards.

Never apply this spray after the bloom opens, for the first ones to open are the strongest apparently, and therefore most liable to set. The spray upon the newly opened bud may render it sterile, besides being a source of danger to bees gathering the poisoned nectar.

This spray will also destroy many curculios which often feed on the young buds.

SECOND SUMMER SPRAY

This is the most important of all the summer sprays. If all the other sprays were given and this one omitted wormy apples would be the result. This is the only spray that can fill the calyx



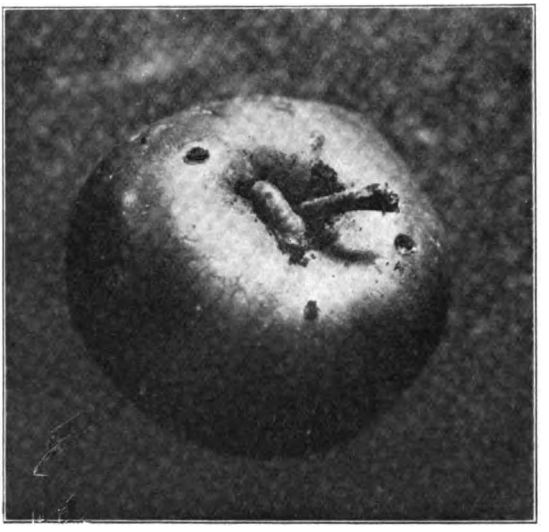
CODLING MOTH AS SEEN UNDER THE SCALES OF BARK ON THE TREE TRUNKS

cup with poison so that the young codling moth of the first brood will be poisoned as it eats its way into the apple. If only one spray is to be applied, let it be this one and do it so thoroughly that no calyx cup is missed. Such an application at this time will almost eliminate the codling moth as a pest for the balance of the year, unless neglected orchards are close or there are haw apple trees near. In another part of this report there is a chapter devoted to the menace of the haw tree, and it is to be hoped that growers will see the necessity of eliminating this tree in the vicinity of their orchards.

Use lime sulphur one and one-fourth gallons to each fifty gallons of water and add one and one-half pounds of powdered

arsenate of lead or two to three pounds of paste arsenate of lead to each fifty gallons.

This will control all the insect pests and diseases which damage the apples at this time, with the exception of aphis and these should have been killed in the early spraying with nicotine sulphate.



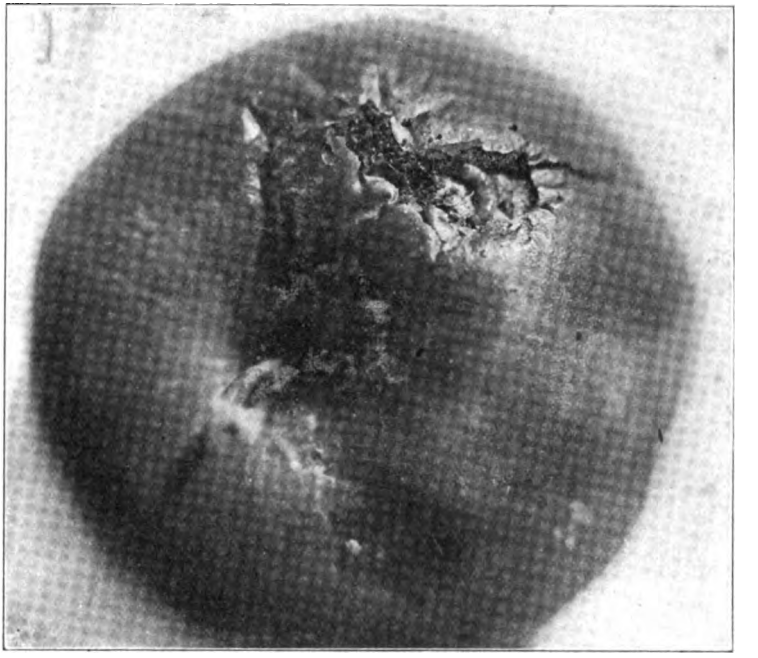
CODLING MOTH OF THE SECOND BROOD WORKING AT THE STEM END OF AN APPLE

Some growers spray the orchard ten days later, using the same mixture, but if the spraying is thoroughly done when the petals fall it will not be necessary to spray again until the second brood of codling moths appear, which is about forty days after the bloom falls.

THIRD SUMMER SPRAY

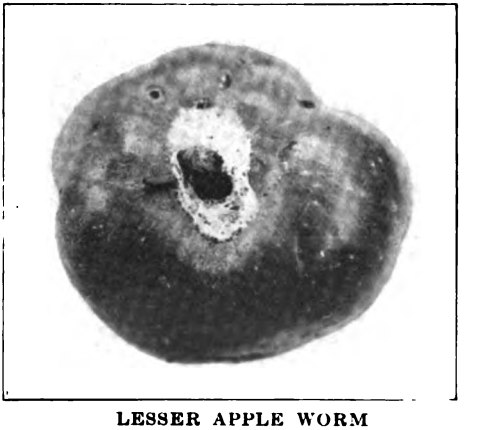
Except in the northern part of Indiana (which is comparatively free from bitter rot and apple blotch) growers must use Bordeaux mixture in this and later spraying for a fungicide. Lime sulphur solution as a summer spray does not control blotch and bitter rot as effectively as Bordeaux. The 4-4-50 solution should be used and directions for making it will be given at the end of this chapter. Add one pound of powdered or two pounds of paste arsenate of lead to each fifty gallons of the mixture to

control any of the following insects, which may show in the orchard at this time: Codling moth, lesser apple worm, Palmer



LESSER APPLE WORM (Enarmonia prunivora-WALSH). The larvae work just below the skin of the apple. The skin has been removed to show the apple.

worm, as well as all of the leaf eating forms which appear. A splendid method of knowing just when this second brood of codling moths appear follows: Gather some green apples which show they contain larvæ of the codling moth and put enough of the apples in a mason jar to fill it two-thirds full, put in a piece of cloth, for the moths to spin cocoons in, and then tie a piece of thin cloth over the top of

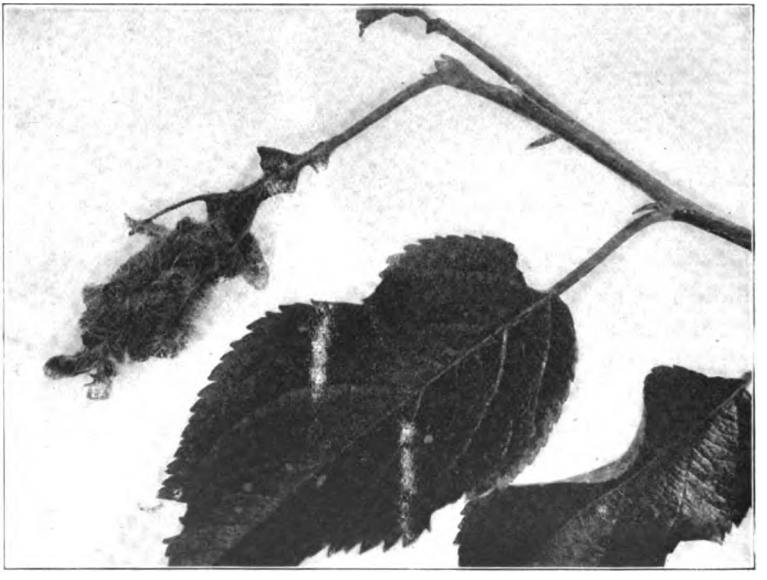


LESSER APPLE WORM

the jar. This should be placed so that it will keep nearly the same temperature as would be found in the orchard. The moths, as was stated before, emerge about forty days after the first spraying, and if the jar is examined each day at that time the grower can tell just when this second brood is emerging and will know that he must get out the spray machine.

ADULT OF THE LESSER APPLE WORM
(Enlarged about 3 X)

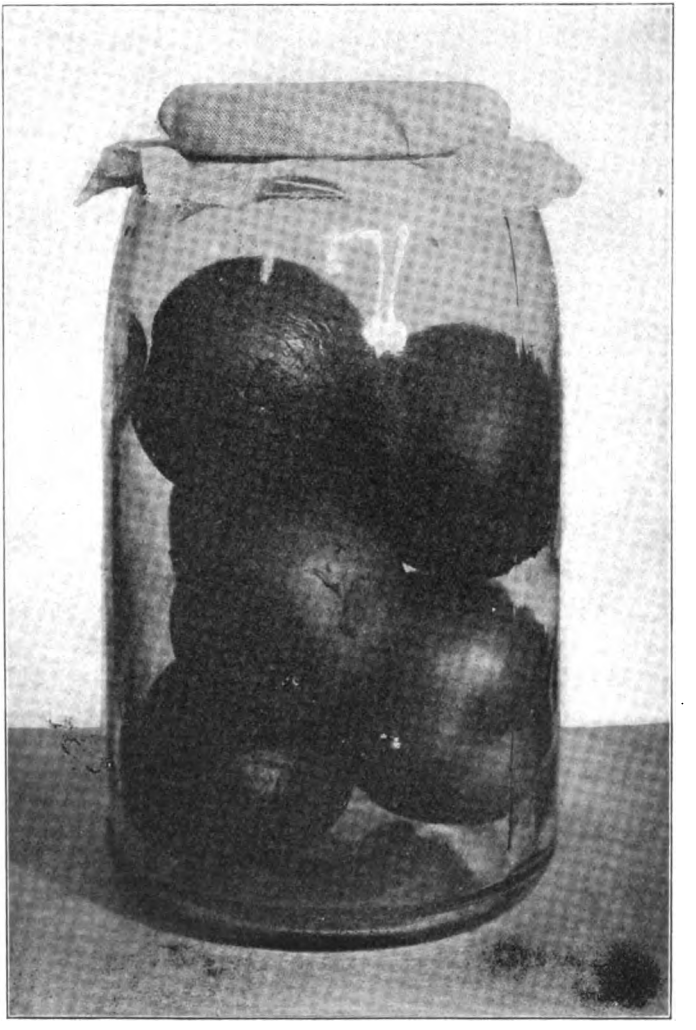
After this third summer spray, weather and insect conditions will determine the later spraying; some seasons possibly one more will give perfect results, but if the season is moist and hot three or four more may be needed. Bordeaux should be used for all of them and the arsenate of lead should also be added. The lesser apple worm is increasing in numbers and the growers in southern Indiana must pay more attention to its work. The



YELLOW-NECKED APPLE CATERPILLAR
(About ½ natural size.)

codling moth control has been worked out, but the lesser apple worm is not watched as closely as it should be. Any grower

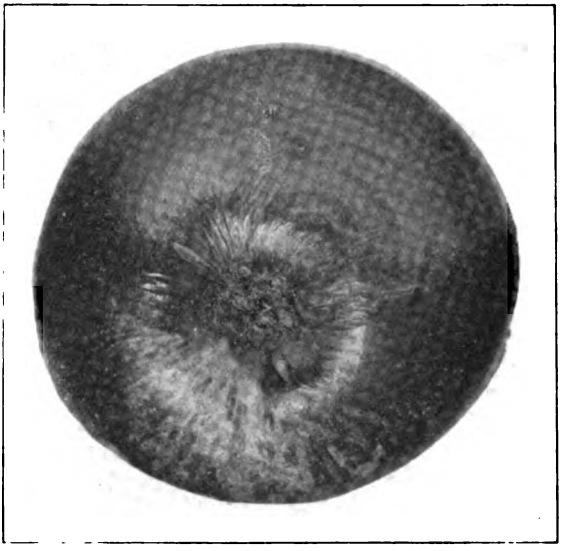
who doubts the existence of this pest in his orchard has only to use the mason jar two-thirds full of wormy apples late in the



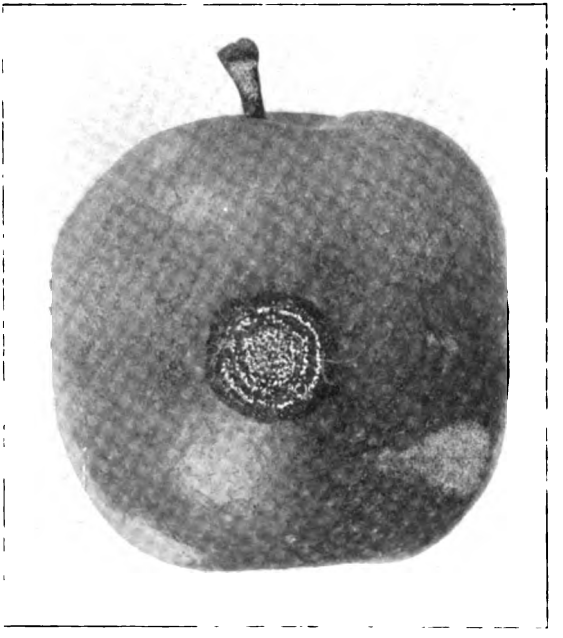
Every fruit grower should use this or a similar method to determine when to spray for the second brood of codling moth. It should also be used to determine whether the lesser apple worm is doing damage

season to see how many of his apples are infested with this pest.

Sooty blotch and fly speck fungus are troublesome in a moist season, and are especially bad if the trees have not been



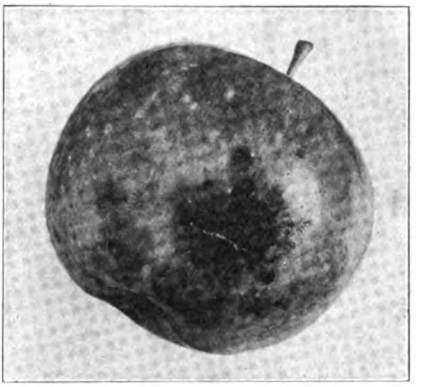
BLACK ROT ON APPLE



BITTER ROT ON GRIMES GOLDEN APPLE

pruned so that light and air can have ready access through the trees. These two diseases are seldom found on apples that get sunshine. The less sunshine an apple receives the more spray material it needs to keep it perfect.

The grower who learns to know the earlier symptoms of the apple diseases on leaves and fruit and keeps vigilant watch over his trees will need fewer applications of spray material.



APPLE BLOTCH ON FRUIT

CHERRIES

Use lime sulphur solution one and one-fourth gallons to fifty gallons of water and add one pound of powdered or two pounds of paste arsenate of lead. Spray just after the shucks have shed from the young fruit. Use a nozzle making a very fine spray and do not spray heavy enough to make the trees drip. A double vermorel nozzle can be used to an advantage when spraying cherries, but the spray rod must be moved rapidly. More spray will adhere to leaves and young fruit if a fine mist remains on the leaves. If applied heavily the spray gathers and runs off and very little sticks to the leaves or fruit. It does not require more than a third as much material to spray cherry trees as it does apple trees.

One spray application is enough to raise perfect fruit, unless the fruit was allowed to rot on the trees the year previous. If such was the case it would be best to spray with lime sulphur, one gallon to seven gallons of water as a dormant spray before the buds swell in the spring, or use one and one-fourth gallons of lime sulphur just before the flower buds open. Brown rot often attacks the stems of the bloom before the fruit sets, and when that occurs no amount of spraying will prevent the fruit falling. This happens frequently with sweet cherries and is the main reason for this fruit not bearing in many parts of Indiana. In Monroe, Morgan and Brown Counties sweet cherries grow to perfection and more money could be made from this crop in these counties than

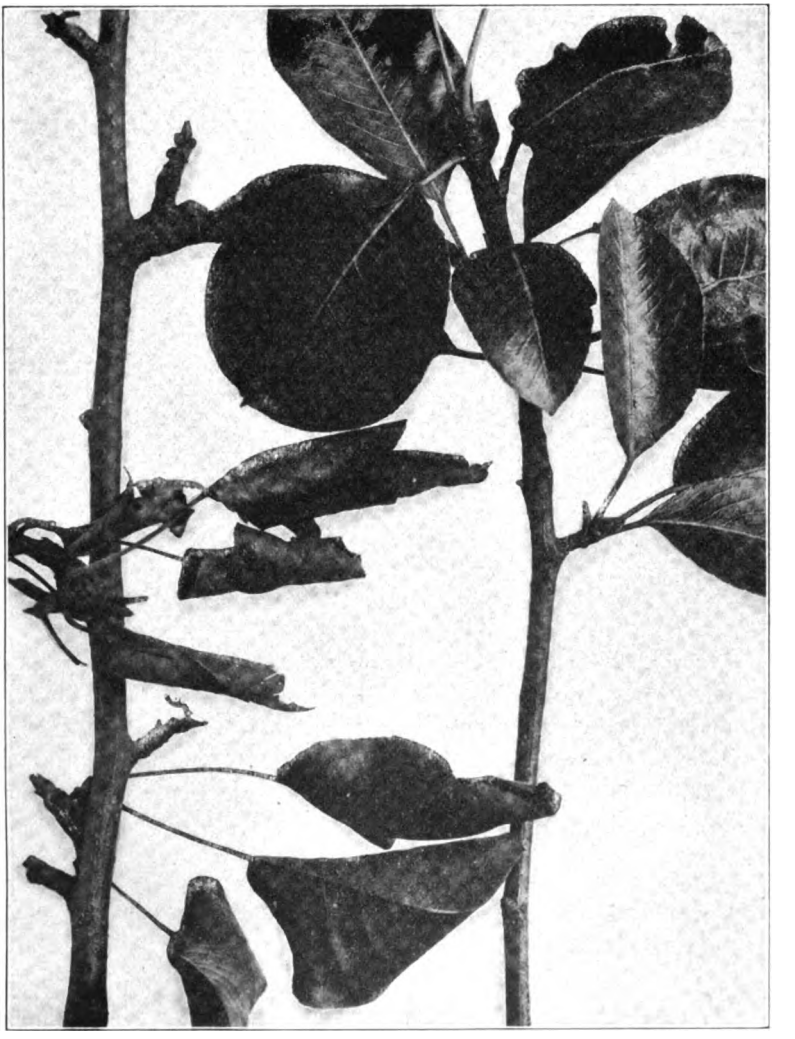
any other crop raised. Any one wishing specific information on this subject should write or come into the office and we can cite many cases of success in growing sweet cherries.

After picking the cherries the trees should be sprayed with one and one-fourth gallons of lime sulphur to each fifty gallons of water or Bordeaux mixture 4-4-50. This will prevent yellow leaf, which is a scourge in some unsprayed cherry orchards. The leaves must be kept healthy throughout the season for the trees to produce a good set of strong fruit buds for the following year.

A CHERRY TREE WHICH LOSES ITS LEAVES EARLY ONE SEASON CANNOT PRODUCE A HEAVY CROP OF FRUIT THE FOLLOWING YEAR.

PEARS

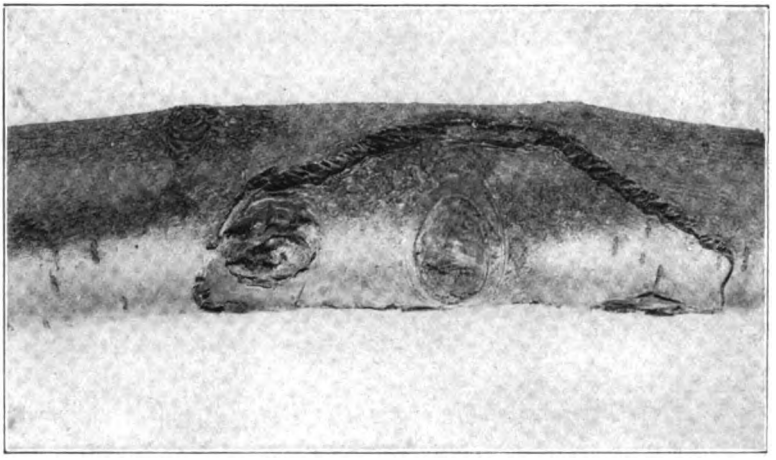
Except in a comparatively few cases very little money is made on pears in Indiana. They are such great sources of infection



FIRE BLIGHT ON PEAR SHOWING HOW DEAD LEAVES REMAIN ON THE TWIG

for blight, that we strongly recommend that Indiana growers do not plant pears, and if you have any old trees on your place which are not productive you will help advance fruit growing in Indiana

by cutting them down. If you have an apple orchard you are placing a possible source of blight infection in each pear tree you plant. The blight epidemic of 1915 should be a lesson which fruit growers should not soon forget. Indiana may, and probably will have a recurrence of the blight epidemic within the next five or six years, unless we can eliminate pear trees, as the blight usually gains a foothold from them.



BLIGHT CANKER. THESE SHOULD BE CUT OUT

If you have a pear orchard and want to raise fruit from it, spraying when the bloom falls, with lime sulphur one and one-fourth gallons to each fifty gallons of water and one pound of powdered or two pounds of paste arsenate of lead added to each fifty gallons is usually all that is needed to protect the crop. If codling moths are prevalent, use the same proportions again in forty days.

KEEP A RECORD OF YOUR COSTS AND RETURNS AND IF THE PEAR ORCHARD IS NOT PRODUCTIVE CUT IT DOWN.

PEACHES

If scale is present give a dormant spray of lime sulphur in the spring before the buds swell, one gallon to six gallons of water. If no scale is present, use one gallon of lime sulphur to fifteen gallons of water before the buds swell. This spring spraying is to prevent peach leaf curl which causes such great loss to peach

growers during cold wet springs. There is no known cure for this disease once it has entered the tissues of the leaves, and the

YOUNG PEACHES SHOWING TIME TO SPRAY FRUIT THE FIRST TIME

spores must be killed before the leaves start to grow if you want to be sure of healthy foliage free from this dreaded disease. The

spores winter over in the bud scales and lime sulphur will kill them if applied in the spring.

Spray with self boiled lime sulphur 8-8-50 to which is added one pound of powdered arsenate of lead or two pounds of paste at the time the shucks have shed from the young peaches. Do not spray before they shed or the solution will not be able to cover the little peaches, and they should be covered so as to poison the curculios when they attempt to feed on the young fruit.

LATER SPRAYINGS

Repeat the above spray in thirty to forty days. This is usually all the spraying that will be necessary for the peach grower.

HOME STORAGE OF APPLES

For eight years I have been a strong advocate of home storage for apples. There are many growers now who use home storage, and on winter varieties obtain as good or better results than by placing in cold storage. More money certainly can be made from the apples stored at home, especially if the grower has a local market.

A concrete storage cellar can be paid for with the saving of the storage and barrel or box charges in one or two seasons, and the grower will then have his storage house for all time. A rightly constructed concrete storage house is practically indestructible and in a very few years I believe almost all apple growers will have one to take care of at least part of the crop.

If the work of the office permits I intend to put out a special bulletin on apple storage houses, giving instructions in detail on their construction and cost.

FUNGICIDES

No. 1. Bordeaux Mixture:

Copper sulphate (blue Vitriol).....4 pounds
Quicklime (not air-slaked).....4 pounds
or hydrate lime 5 pounds.
Water to make 50 gallons.

The equipment should consist of a 50-gallon barrel, two 25-gallon tubs, a couple of buckets and a paddle. The tubs are placed one on each side of the barrel. In one, the four pounds of copper sulphate, in a coarse sack, are dissolved in ten gallons of hot water and diluted to 25 gallons. In the other tub the lime is slaked, only sufficient hot water being used to make it form, when thoroughly slaked, a thick paste. In this form the lime should be diluted to twenty-five gallons. The two solutions are then ready to be mixed, two persons being necessary for this operation. The contents of each tub are kept well stirred and a bucket each of milk of lime and sulphate solution are poured into the barrel simultaneously, care being taken to allow the two streams to come together. This process is continued till the entire amount is made. The blue mixture in the barrel is thoroughly agitated, strained through a thirty-mesh to the inch wire strainer, into the spray tank and applied. For such trees as are injured by the 4-4-50 formula a mixture of two pounds of copper sulphate, two pounds of quicklime and fifty gallons of water may be used.

COPPER SULPHATE STOCK SOLUTION AND LIME PASTE

Where large amounts of Bordeaux mixture are to be made for several sprays much valuable time will be saved by having a stock of the materials. If no lime is added to it, a solution of copper sulphate that contains a pound of sulphate to each gallon of water may be made and if covered it can be allowed to stand indefinitely. From two to four gallons of this stock solution (according to the strength of Bordeaux mixture desired) is taken for each fifty gallons of the mixture to be made.

The lime should be slaked and kept in a long trough or box of uniform width. The proper amount of quicklime is weighed out, placed in the trough and slaked with a small quantity of

water. The resulting paste is spread out evenly in the trough and covered with water to exclude air. Calculated portions of this paste are placed in a tub and treated like freshly slaked lime. It must be borne in mind that it is always better to combine the sulphate and milk of lime solutions diluted to volume rather than mixing the concentrated solutions.

The present very high cost of copper sulphate (blue vitriol or bluestone) makes spraying with Bordeaux mixture expensive but there is no satisfactory and efficient substitute for it where its use has been recommended in the spray calendars.

No. 3. Self-Boiled Lime-Sulphur Solution:

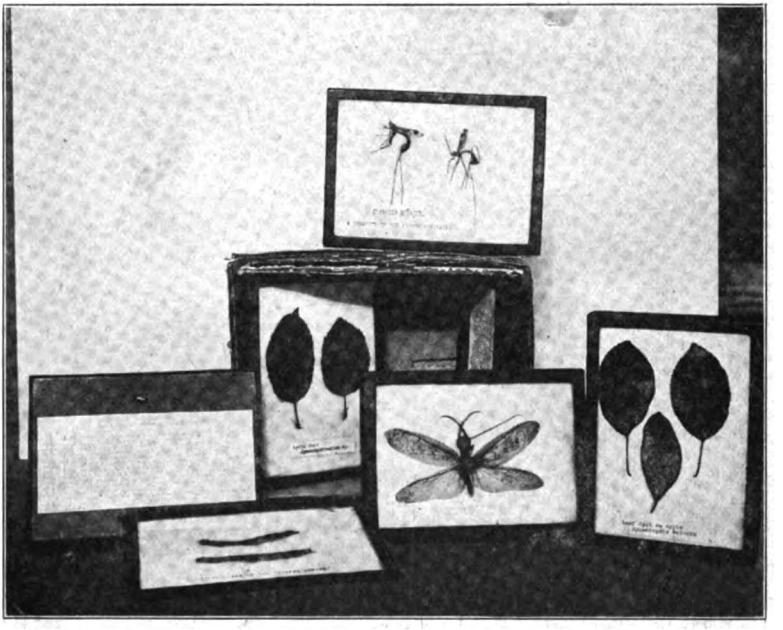
Stone lime	8 pounds
Sulphur	8 pounds
Water	50 gallons

This fungicide has become famous in the control of brown rot in stone fruits. It is especially valuable as a fungicide on peaches and Japanese varieties of plums because it does not injure the foliage. This mixture can be made in any quantity desired by using materials in proportion to the above formula.

The lime is placed in a barrel and enough water is added to barely cover it. Sulphur that has first been run through a sieve to break up the lumps is added as soon as the lime begins to slake. This mixture should be stirred constantly and water added to form first a thick and gradually a thin paste. The slaking of the lime supplies enough heat, and this with the constant stirring produces the desired mechanical mixture of lime and sulphur. After from five to fifteen minutes (depending upon whether the lime is quick-acting or sluggish) water is added to cool the mixture and prevent further cooking. The mixture should be strained into the spray tank (care being taken to work all the sulphur through the strainer), diluted at once, and applied. If allowed to stand too long before dilution the sulphur tends to unite with the lime, forming at the end of half an hour enough reddish liquid or regular lime-sulphur solution to seriously burn peach foliage and sometimes even apple foliage.

RYKER MOUNTS FOR SCHOOL USE

The Entomologist's office has a fine collection of Ryker Mounts, showing many of the common insects of the State, as well as a few of the rare ones. We also have some showing diseases of trees and plants. These are principally used at the State and County Fairs, but I thought it advisable to put these to some use when they were not at such exhibitions, so decided to allow the schools which were interested the use of them. Teachers who are interesting the pupils in insect and plant life, particularly the schools in rural districts, find these very useful.



A COLLECTION OF RYKER MOUNTS READY TO BE SHIPPED

We now have shipping cases holding ten of these Ryker Mounts, which we will loan to any school requesting the use of them. Part of them will be insect and part plant disease studies. A short description is pasted on the backs of each, so that they are self explanatory.

Any teacher interested in this line of work can secure the use of these mounts by writing to the State Entomologist's office, 130 State House, Indianapolis, and a set will be sent which can be kept a week or ten days, and then mailed back to this office.

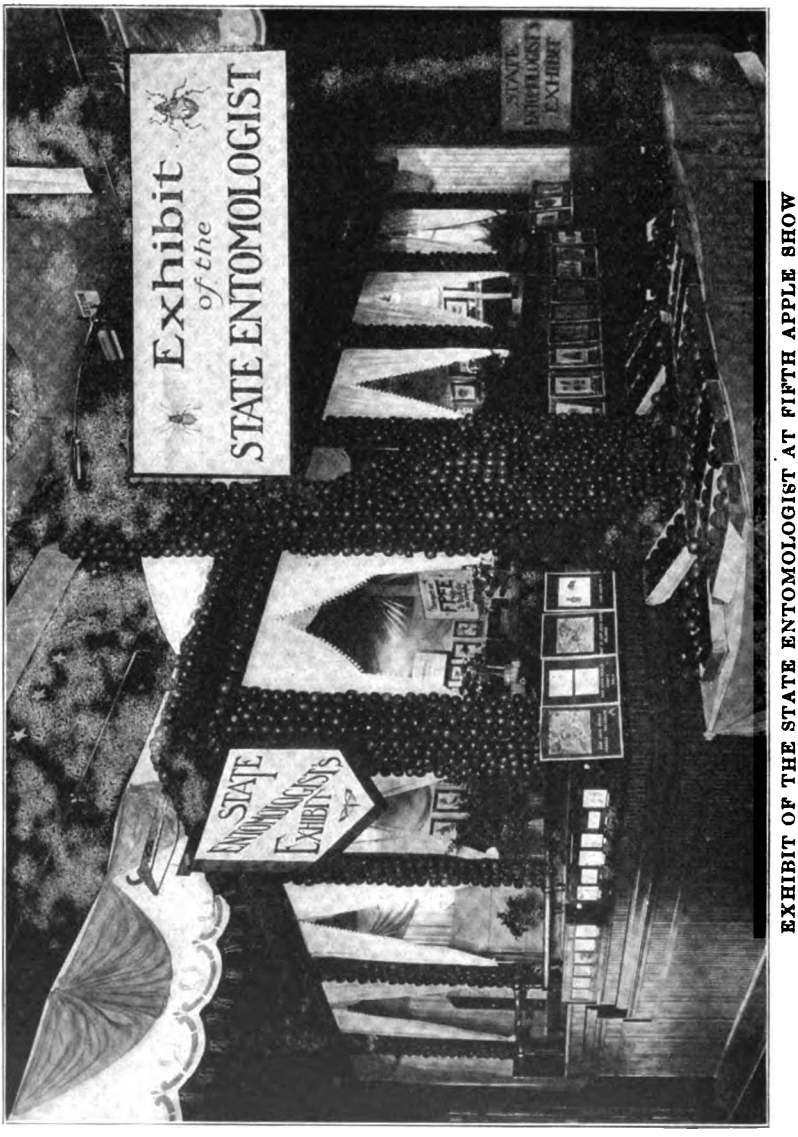
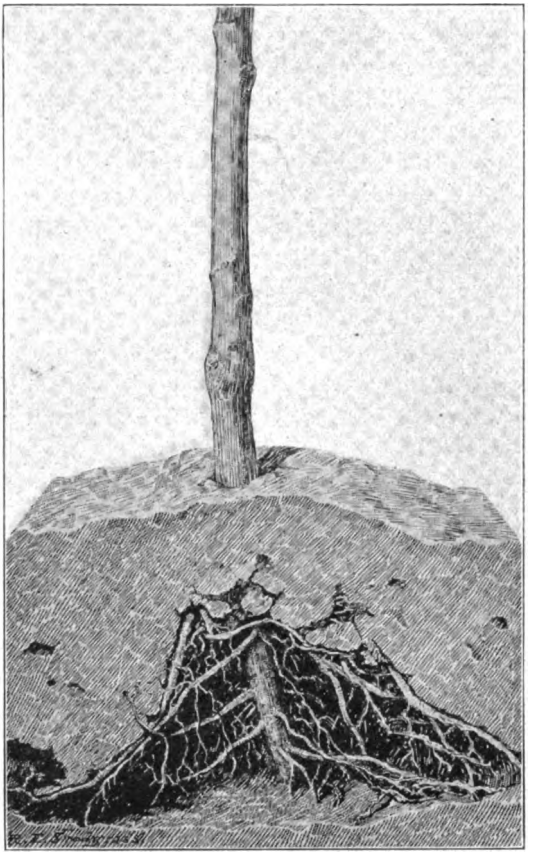


EXHIBIT OF THE STATE ENTOMOLOGIST AT FIFTH APPLE SHOW

THE FIFTH INDIANA APPLE SHOW

The Fifth Indiana Apple Show was held in Indianapolis, November 6th to 13th. The office had an exhibit there as in previous years. The insect pests and diseases of the apple were shown as well as many pests and diseases of other fruits. While it was primarily an apple show, most of the people who came to the



THE WRONG WAY TO PLANT A TREE. THE SOIL SHOULD BE TRAMPED AROUND THE ROOTS

exhibit were also interested in other lines of fruit growing and our display covered the various phases of fruit raising in Indiana.

A moving picture machine was installed and a reel, which is the property of the Apple Show Commission, called "Apple Growing in Indiana" was shown several times a day and attracted

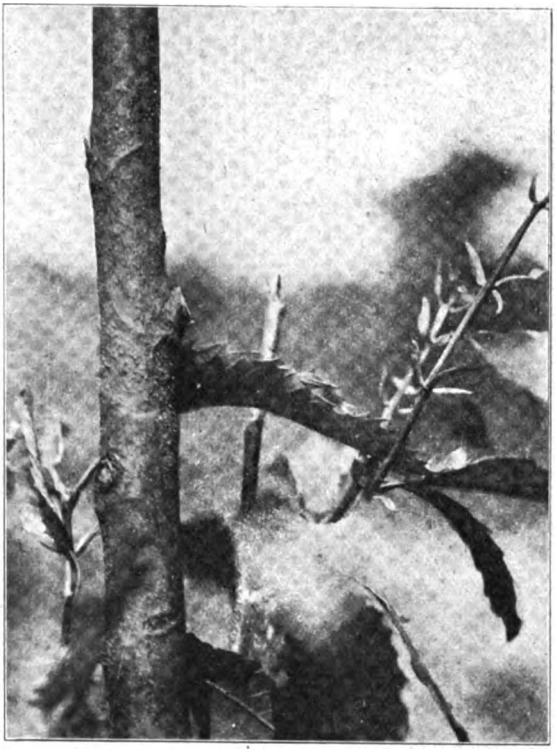
much attention. This reel depicts apple growing from clearing the hill ground through the various phases until the fruit is finally sold on the retail market.

Another point clearly brought out at our exhibit was the proper way to plant a tree. A young apple tree was set in a box with a glass front and all the soil thrown in before any of it was packed around the roots. This left an air space underneath the packed surface which in a dry season permits the roots to dry out and the tree dies. Many people who stopped to ask about the tree said they never before realized the importance of tramping the soil around the roots until the hole was entirely filled. We have estimated that fifty per cent of the young trees which die the first season after being set, do so from this cause. Some of the nurserymen who visited the exhibit claimed that at least seventy-five per cent of the trees dying the first year do so from improper planting. The cut will show just what happems when the soil is not tramped in firmly as the hole is being filled. If school teachers will impress this fact upon the children, fewer failures would result from their efforts in tree planting. This idea would be especially appropriate just before Arbor Day.

Another phase of our exhibit which elicited many questions was trees affected with crown gall, hairy root and woolly aphis. Visitors were instructed not to accept stock showing any signs of these diseases or pests. Reliable nurserymen always endeavor to throw away all trees which are so affected, but sometimes a few are sent out by careless packers, but such trees should never be planted.

CHESTNUT BLIGHT

My attention was called to this disease last fall by one of the deputies saying that two chestnut trees planted by him in the northern part of the State had died of blight. The trees came from the C. K. Sober nurseries in Pennsylvania, and we made every effort to trace out all shipments of chestnut trees which he had shipped to Indiana. We found about thirty-five per cent of all the trees had died from this disease, and that the disease came on the trees. We protested to the Pennsylvania authorities, and now no chestnut trees can be shipped from the blight area in Pennsylvania. We hope that this disease can be eradicated in Indiana, and ask that everyone having any trouble with their chestnut trees send us samples of the dead or dying trees. The photograph shows the nature of the disease when the canker gets old enough for the blight to spread.



CHESTNUT BLIGHT SHOWING CANKER WHICH KILLED UPPER PART OF THE TREE

RUST ON ASPARAGUS
(From Bul. No. 263, B. P. I. U. S. Dept. of Agr.)

SOME COMMON DISEASES OF VEGETABLES

BY J. B. DEMAREE

ASPARAGUS

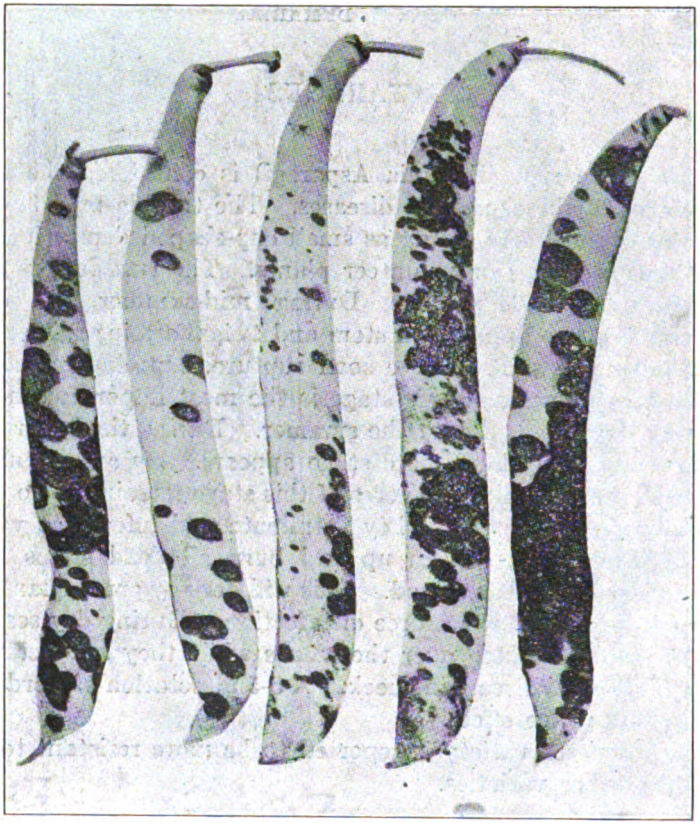
Rust. The rust (Puccinia Asparagi) is considered the most destructive of the asparagus diseases. The trouble may first be observed during early spring as small cup-shaped depressions on stems and seedlings or volunteer plants. The rust fungus does not attack the edible shoots. During mid-summer the most destructive phase appears on stem and twigs forming blister like spots under the skin. These soon rupture, exposing masses of reddish-brown spores. This stage is the most important in dis tributing the fungus during the summer. During the latter part of the season the black spore stage appears. Its appearance is similar to the preceding. Spores of this stage remain viable until the following spring when they germinate and infect the young plants. Treatment.—Clean up and burn all dead stems after the seasons growth has ceased. This will destroy great quantities of spores, which are the source of infection. During dry seasons flour of sulphur dusted over the plants while they are wet with dew will keep the disease in check. A 5-5-50 solution of Bordeaux mixture will prove effective.

The Palmetto variety is reported to be more resistant to the rust than other varieties.

BEAN

Anthracnose (Colletotrichum Lindemuthianum). This disease attacks pods, stems and leaves. The most conspicious injury is done to the green pods. The disease first appears as small brown spots, which enlarge rapidly, forming dark depressions. Under favorable conditions these spots become pinkish in color, due to the formation of spores. The mycelium of the fungus extends through the pod into the bean, causing a discoloration of the latter. Distribution of the fungus another year is assured through

such infected seed, as the fungus mycelium remains dormant here until it is placed under favorable conditions of warmth and moisture. Warm damp soil is an ideal place for its development.



BEAN ANTHRACNOSE
(From Bul. No. 239 New York (Cornell) Agr. Exp. Sta.)

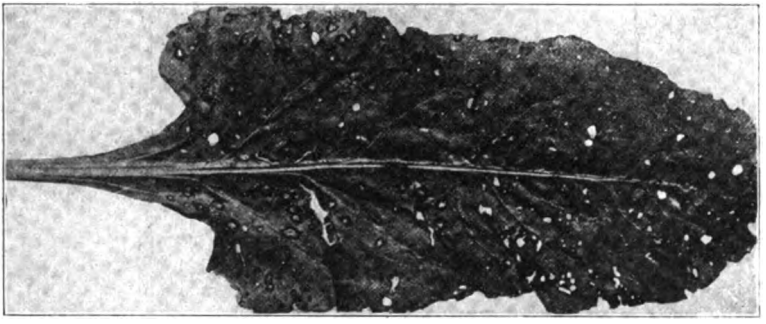
Remedy.—Seed selection is the most important means of controlling this disease. It is not, however, sufficient to select seed apparently free from infection for many minute infections will be overlooked. The surest method is to select seed from healthy pods, preferably from a field which is free, or practically free of the disease.

Spraying with Bordeaux mixture, 5-5-50 formula is to be advised when the disease first appears. Crop rotation must also be practiced.

Rust.—(Uromyces appendiculatus). The rust causes a yellowing and subsequent dying of the leaves with a production of dusty red rust spores. The disease is usually more destructive to late plantings than to the early crop. In severe cases the fungus attacks not only the leaves, but stems, petioles and pods. Rotation of crops and burning of the vines and leaves are the only practical means of keeping the disease in check.

BEET

Leaf-Spot (Cercospora Beticola). This causes spots to occur over the entire surface of the leaves. In color these spots range from brown to grayish, surrounded with a purplish margin. Severe cases entirely kill the infected leaves, causing them to drop from the plant. A 5-5-50 Bordeaux mixture will materially check the disease.



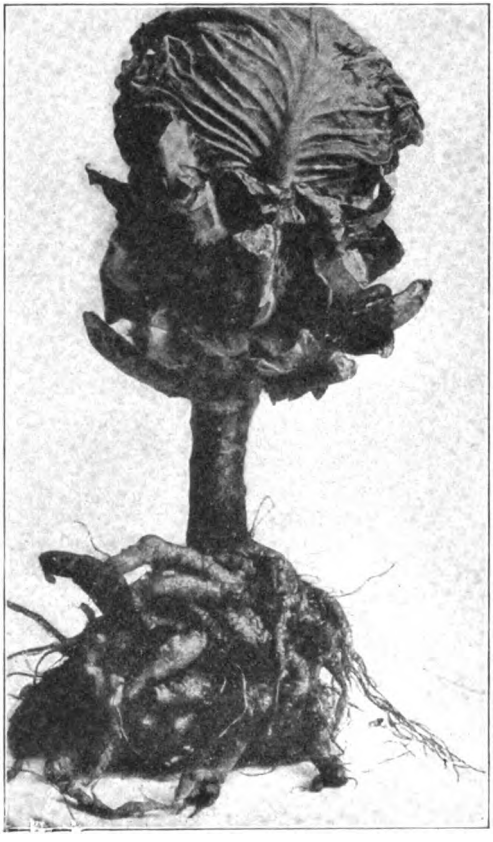
LEAF SPOT OF BEET
(From Farmer's Bul. No. 618, U. S. Dept. Agr.)

Beet Scab (Oospora scabies). The beet scab is caused by the same organism causing the common potato scab. It causes a roughened, and sometimes almost warty condition of the beet surface. Beets should not be planted in soil that has previously grown scabby beets or potatoes.

CABBAGE

Club Root.—(Plasmodiophora Brassicae) produces large swellings on the roots, stunting and frequently causing death of the plants. The club root organism also attacks turnips, mustard, rutabaga and other closely related plants. The disease lives in

the soil and may survive there for several years. Soil once inoculated with the organism should be planted in such crops as corn, wheat or some non-cruciferous crops for a number of consecutive years before it is again planted in cabbage. Experiments have proved that an application of 75 to 80 bushels of fresh



CLUB ROOT OF CABBAGE
(From Bul. No. 185, Vermont Agr. Ex. Sta.)

stone lime per acre, thoroughly incorporated into the soil will materially reduce the danger of infection. No other practical means of controlling the disease is known at present.

Black Rot (Pseudomonas campestris). This is a comparatively new disease of cabbage and other closely related plants as kale, turnips, cauliflower and mustard. The causitive organism, which is a bacterium, enter the cabbage plants through the pores

at the margins of the leaves, causing them to first present a burnt edge appearance. Later the infected leaves turn yellow, except the veins, which become brown or black. Presumably the disease passes down through the leaves and up through the stem to the head, ultimately rotting the entire head.

Treatment.—The disease may be carried from field to field by infected plant parts, or by farm implements being dragged from an infected field to a field free of the disease. The disease may also be carried from one section of the country to another on cabbage seed. Just previous to planting, seed should be soaked for fifteen minutes in a solution of mercuric bichloride one part to one thousand parts water; or formaldehyde one part to two hundred parts water for twenty minutes. The seed bed should be changed frequently, as this is often the principal source of infection. Practice a crop rotation or cease planting cabbage in your fields for a few years. Insects, especially grasshoppers are very largely responsible for the distribution of the disease in the field.

CELERY

Blight or Leaf Spot.—Two species of leaf spot fungi attack celery. One (Cercospora apii) causes large irregular spots on the leaves during the summer. This disease is common here, but is not considered especially injurious to the crop.

The Winter Blight.—(Septoria petrosetini) causes smaller but more numerous spots than the preceding. This disease causes a stunting in growth, and a decay of the leaves and stems in storage and shipment. Frequent applications of Bordeaux mixture will lessen the injury by this fungus.

Root and Stem Rots.—Under such conditions as wet cold weather, poorly drained soil with a high acid content, soil fungi will frequently cause decay of the roots and stems. Such troubles can only be prevented by removing the unfavorable condition.

CUCUMBER (See Melons)

EGG PLANT

Anthracnose.—A fungus causing depressed spots on the fruit. Not serious.

Bacterial Wilt.—Causing wilting and subsequent dying of the plants. It is caused by the same organism (Bactarium solanacearum) that causes tomato wilt. Wilted plants should be promptly pulled and burned.

ROOT ROT OF CELERY
(From Cir. No. 73, Ohio Agr. Exp. Sta.)

LETTUCE

Downy Mildew.—(Bremia Lactucae). The symptoms of this disease are downy covered areas on the under side of the leaves, and is manifested on the upper surface as yellow spots. This trouble can be controlled in the greenhouse by regulating the heating, ventilating and watering of the beds. Avoid too high temperature or too free applications of water.

Lettuce Drop.—This fungus (Sclerotinia Libertiana) causes the lettuce grower more trouble than all others combined. The plant rots off at the surface of the ground, and finally the entire plant decays down in a soft mass. It has been clearly demonstrated by experiments that the beds can be entirely freed of this disease by promptly removing all plants when showing the first symptoms of this disease.

MELONS

Anthracnose.—(Collectotrichum Lagenarium). The Anthracnose of melons, cucumbers and squashes is a disease of both fruit and leaves. It causes irregular rusty spots on the latter, and water soaked, sunken spots on the fruit. This disease does not cause a deep rot, but it mars the appearance of the melon and greatly reduces its market value. This disease can be partly overcome by spraying the vines every ten days or two weeks with Bordeaux mixture of a 5-5-50 formula.

Bacterial Wilt.—(Bacillus tracheiphilus). This is considered the most serious disease among curcurbits in the United States. The symptoms consist of a progressive wilting of the entire plant. Infection usually takes place at the distal end of the vine. From there the wilting gradually progresses to the main stem, then other runners become infected and wilt. Insects, especially the striped cucumber bettle, are largely responsible for the spread of the disease. All wilting vines should be removed as soon as noticed.

ONION

Dry Rot.—(Sclerotium cepivorum). This is principally a storage trouble, and is confined mainly to the white varieties, that are grown for special markets, where it is the practice to harvest early before the tops mature in order to produce an extra white product. When onions are harvested at this stage the

green tops are pulled off, leaving an inviting place for entrance of disease. A decay sets in at this point, later forming conspicuous black masses at the top end. Crop rotation is the only present known method of controlling this disease. Onions decayed by this fungus should never be hauled to the field, but should be buried or burned.

Smudge.—(Vermicularia Circinans). This disease is not a serious one, as it causes no rot of the onions, only superficial spotting of the outer layers. It is often, however, sufficiently severe to reduce their market value.

Smut.—(Urocystis cepulae). Only very young onions are susceptible to attack of this fungus. It attacks the lower portions of the first leaves, causing them to wither and fall. Later longitudinal rifts are formed on leaves and bulb, these burst, exposing masses of spores. Infected soil is the chief source of trouble. In small plots or gardens the trouble can be prevented by transplanting seedlings that have grown in disease free beds. For field practice a solution of formaldehyde at the rate of one pound to thirty gallons of water can be sprinkled in open furrows, after the seeds have been sown, or applied with a special formaldehyde drip attachment on the seeder at the rate of one hundred twenty-five to one hundred fifty gallons per acre. This method of treatment is quite effective.

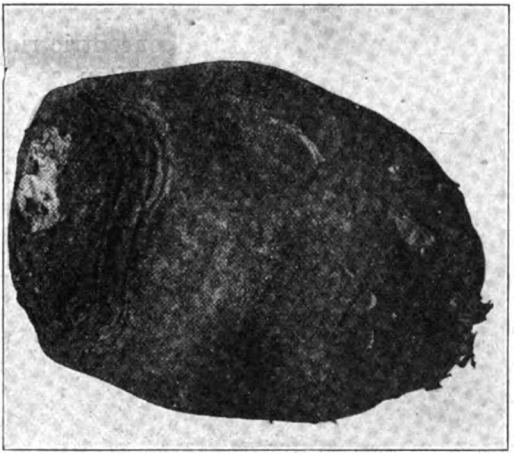
PEA

Anthracnose.—(Ascochyta Pisi). The anthracnose of the pea is very similar to the bean anthracnose in its method of attack. It infects stems, leaves and pods. The fungus thread extends through the pod into the pea, thus infecting seed for the next years crop. Diseased seed gives rise to diseased seedlings and causes a loss of the crop. The most practical methods of controlling this disease are to practice crop rotation and plant seed grown from healthy plants. Spraying with Bordeaux mixture will also aid in controlling the trouble.

Powdery Mildew.—(Erysiphe comminis). The mildew is frequently quite severe in this state, and causes complete loss of the crop; the fungus causing a whitish covering upon the leaves. Thorough spraying with Bordeaux mixture will prevent the disease.

POTATO

Fusarium Blight (Fusarium oxysporum). This fungus causes both a disease of the vine and rot of the tubers. The trouble is not distributed generally throughout the State, and its attack is influenced very much by climatic conditions. During the rainy



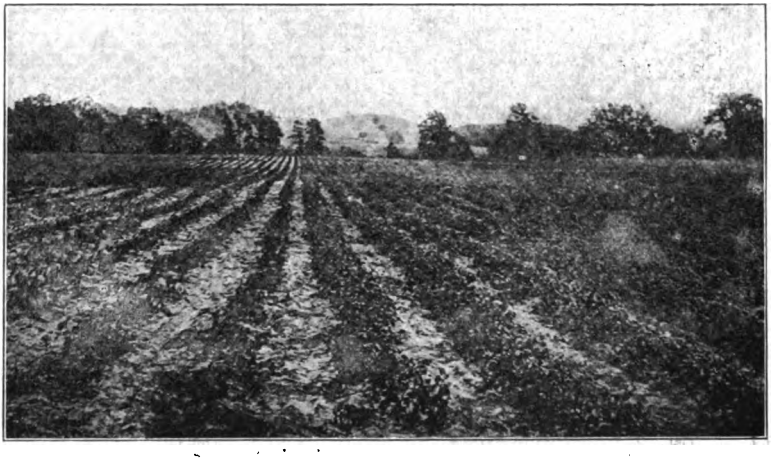
FUSARIUM DRY ROT OF POTATO
(From Special Bul. No. 66, Mich. Agr. Exp. Sta)

FUSARIUM ROT OF POTATO
Showing production of spores
(From Bul. No. 229, Ohio Agr. Exp. Sta.)

season of 1915, it caused a heavy loss to the growers of Indiana. The fusarum disease causes wilting, yellowing, and in severe cases dying of the tops. Infection seems to take place on the roots. Insipient infection of the tubers cannot be detected unless they are

cut crosswise, when the disease will show by the vascular ring being discolored. In storage, however, and often in the field, this ring will become black. A dry rot will set in at the stem end, that will sooner or later involve the entire tuber. For control practice crop rotation.

Early Blight (Macrosproium Solani). A leaf blight, causing brown circular, or elliptical spots with concentric ring to appear on the potato leaves. These spots are often so numerous as to materially impair the functions of the leaves, consequently reducing the yield. Frequently applications of Bordeaux mixture will prevent the disease.



PHOTOGRAPH SHOWING RESULT OF SPRAYING POTATOES WITH BORDEAUX MIXTURE FOR CONTROLLING LATE BLIGHT. ROWS ON RIGHT BEING SPRAYED
(From Bul. No. 135, Wisconsin Agr. Exp. Sta.)

Late Blight (Phytophthora infestans). The late blight of potatoes is no doubt the most disastrous in the region where it occurs. This disease is seldom seen south of the latitude of Columbus, Indiana. It occurs in the northern section of the State, periodically during season, accompanied by excessive moisture and low temperature. The symptoms are very marked and characteristic. Upon the leaves the fungus produces spots, frequently beginning at the margin and under favorable conditions rapidly involves the entire leaf. The spots have a dark water-soaked appearance, often with a purplish tint. Spores are formed in abundance on these spots that are distributed over the field by the wind. Plants infected with late blight will,

within a few days of good blight producing weather, present the appearance of being severely frosted. Spores from the infected leaves are carried into the ground by rain or insects and there infect the tubers, causing a dry rot. Control methods consist in spraying thoroughly every week or ten days, as long as practical with Bordeaux mixture, during an attack of blight.

Potato Scab (Oospora scabies). This is a well known, and widely distributed disease of the potato tuber, that needs no description. The scab producing organisms have the power to live over in the soil from one season to the other, therefore it is very important to rotate. Potatoes planted in freshly manured, or recently limed soil, are likely to produce a crop of scabby potatoes. To secure potatoes free of scab, clean tubers should be planted in soil free from the scab fungus.

Seed treatment consists in immersing the tubers for about two hours in a solution of one ounce of formaldehyde to every two gallons of water, or in a solution of bichloride of mercury, made by dissolving one ounce of the compound to eight gallons of water for the same length of time.

Either treatment may be done several days previous to planting, providing the treated potatoes are not exposed to re-infection or placed in boxes or bags previously holding scabby potatoes, unless the boxes or bags have also been soaked in the solution.

SWEET POTATO

Black Rot (Ceratocystis fimbriata). This fungus is directly responsible for the abandonment of commercial growing of Sweet Potatoes in some localities. The writer can testify to this by his own experience with this crop in Southern Indiana. The most dreaded phase of the disease is what is known as the "Black Shank", by which name the disease is known by many growers. This stage begins in the hotbed, and frequently before the plants are transplanted to the field the roots and stems below the surface of the ground are black and soft. Incipient stage of "Black Shank" may appear as a brown or black spot on the stem near the old seed-root. Dead blackened roots will often be the first indication of the trouble. Diseased plants transplanted to the field will refuse to grow, turn yellow and finally die. Or if they should struggle through the season they will produce diseased roots, that if planted the following spring will inoculate the seed

bed and be the source of trouble for another year. The fungus also causes spots and decay on the potato. We know of but one sure method of overcoming this sweet potato trouble, i. e., select "seed" from fields absolutely free of the disease; plant only smooth, clean roots, in soil you know is not inoculated by the disease spores; discard all plants at transplanting time that show any symptoms of the disease and plant in a field that did not grow sweet potatoes the year previous.

Bin Rot (Rhizopus nigricans). The bin rot fungus is one of our most common molds that attack many forms of vegetable matter. It causes a soft rot of sweet potatoes in storage, if the house is kept at too high a temperature and is not properly ventilated. This same mold causes the soft-rot in the seed-bed. The soft-rot in the seed-bed can be thoroughly controlled by soaking the roots just previous to layering with bichoride of mercury one ounce to eight gallons of water for fifteen or twenty minutes.

TOMATOES

Fusarium Wilt.—The first symptoms of this disease is a yellowing of the lower leaves, which soon dry up without spotting. Later the entire plant becomes sickly looking of unhealthy color, followed by symptoms of wilting. The disease attacks plants of all ages. After they have begun to set fruit seems to be the most susceptable stage. The wilt fungus ordinarily does not affect all the plants in the field at the same time, but the trouble comes in gradually wilting a plant here and there. In badly infected soil, however, all plants will die before the end of the season.

This trouble is not confined to field conditions alone, but also causes enormous loss to greenhouse men.

Treatment.—As the wilt fungus is within the stem and roots of the tomato plant, no advantage will be gained by spraying. Only sanitary methods of control will yield results. Particular attention should be given to the seed-bed. Seed should be sown only in clean, disease free soil. The seed bed should either be changed each year or the old bed treated with formaldehyde or steam. Greenhouse soil once inoculated with spores of the wilt fungus must either be changed or sterilized. Proper attention given to the seed beds and a system of crop rotation will almost assure immunity against this disease under field conditions.

Mosaic Disease.—The symptoms of this disease are striking and conspicious. The ordinary indications are that the leaves become mottled with a coloring of yellow and green. Plants affected with this trouble often produce an abnormal growth, either a lengthening of the leaves and internode or a narrowing of the leaves, or a combination of all symptoms. Often the leaves are narrowed to mere skeletons. Mosaic plants are non-productive, and should be destroyed as soon as observed. The remedy is pointed out by the fact that the disease may be transmitted by first touching diseased then healthy plants.

Septoria Blight (Septoria Lycopersici). This is the most widely and generally distributed tomato disease we have to contend with. It first appears as small inconspicuous spots on the lower and older leaves. The disease progresses upward rather rapidly, killing the leaves and causing them to fall. During seasons favorable for the blight disease, the entire crop may be destroyed.

SEPTORIA BLIGHT OF TOMATO
All lower leaves have fallen off.
(From Bul. No. 192, Virginia Agr. Exp. Sta.)

Treatment consists in planting the seed in disease free beds. Many growers make the mistake of allowing unused plants to mature in their seed beds. These plants invariably become diseased and thoroughly inoculate the seed bed soil. Plants grown in soil infested beds will become diseased before transplanted to the field.

A 5-5-50 formula of Bordeaux mixture applied every ten days or two weeks until the plants become too large, will effectively control this disease. The first two sprayings should be done in

the beds, while the plants are small. A good practice to follow is to spray just previous to transplanting, then allow an interval of about three weeks after the plants have been transferred to the field before giving the next application.

Bacterial Blight.—Causing sudden wilting of the plant, and later death. The bacteria which causes this trouble lives within the tissues of the plant, thus clogging the vascular system, preventing the movement of water and food from one part of the plant to another. Spraying will not control or prevent this disease. Wilting plants should be pulled and removed from the field as soon as noticed.

End Rot.—Tomatoes rotting at the blossom end, especially during the beginning of the ripening season is a very common occurence. This is a physiological trouble due to scant water supply. The end rot is especially severe during a drouth. Cultivation in the field is usually impossible at the ripening season, owing to the large size of the vines. The trouble in the greenhouse can be controlled by supplying the plants with a greater quantity of water.

DIRECTIONS FOR STERILIZING SOIL IN PLANTBEDS AND GREENHOUSES

J. B. DEMAREE

It is generally understood by those who are engaged in gardening and greenhouse work that the soil is inhabited by insects and other organisms, microscopical in nature. Also it is understood that some of these organisms are useful in breaking down compounds, making them available for plant food, while other soil organisms are extremely harmful to the plants growing in the soil. How to treat the highly valuable soil in such a way as to destroy the undesirable soil organisms without injuring the productivity of the soil is one of the intricate problems the intensive gardener and greenhouse man have to solve.

The cost of producing flowers and vegetables is high and is on the incline, and the grower cannot afford to plant a crop that may result in only a partial stand, sickly, slow growing plants, or a low yield.

The grower may have built his soil up to a high state of fertility; he may have planted his seeds, plants or cuttings at the proper time in soil of good till; he may follow proper methods of watering, heating and ventilating, but if his soil has been used for several years without treating, it may be so badly infested with parasitic micro-organisms that the crop will be unable to produce its maximum yield.

In order to be able to combat an insect or fungous enemy one must first understand its nature. These harmful soil organisms may be either low microscopic forms of animals or plants, generally either fungi or bacteria. Some forms are capable of living, thriving and multiplying while subsisting upon the decaying vegetable matter in the soil, in fact these organisms cause the manure, compost, and other forms of vegetable matter in the soil to decay and thus liberate the imprisoned plant foods. We would not object if the fungi and bacteria were content to procure their subsistence from the dead matter in the soil, as they render us a great service in doing this, but on the other hand they persist in attacking the seeds that are planted in the soil, causing them to rot. They attack the young seedling underneath the top of the soil, or just at the surface, causing the plants to "damp off". These soil organisms also attack mature plants, causing such common maladies as lettuce rot, tomato wilt, cucumber

wilt, carnation yellows, rotting of cuttings, damping off of seedlings, and have been reported to attack other plants of less importance as ornamental asparagus, china aster, sweet william, violets, begonia, coleus, verbena, phlox, snap dragon, etc.

The last two decades have witnessed the recommendation of a number of methods for the destruction of these plant disease producing soil organisms. Only three are sufficiently important to consider in this paper. These three methods essentially involve two principles: First, sterilizing the soil by subjecting it to a high temperature by steam, either by the perforated pipes or the inverted pan method. Second, sterilizing the soil by drenching it with formaldehyde. These three methods will allow sufficient elasticity to be adaptable by all. The steam sterilization methods can be used by forcing—house men and those having a portable boiler or engine.

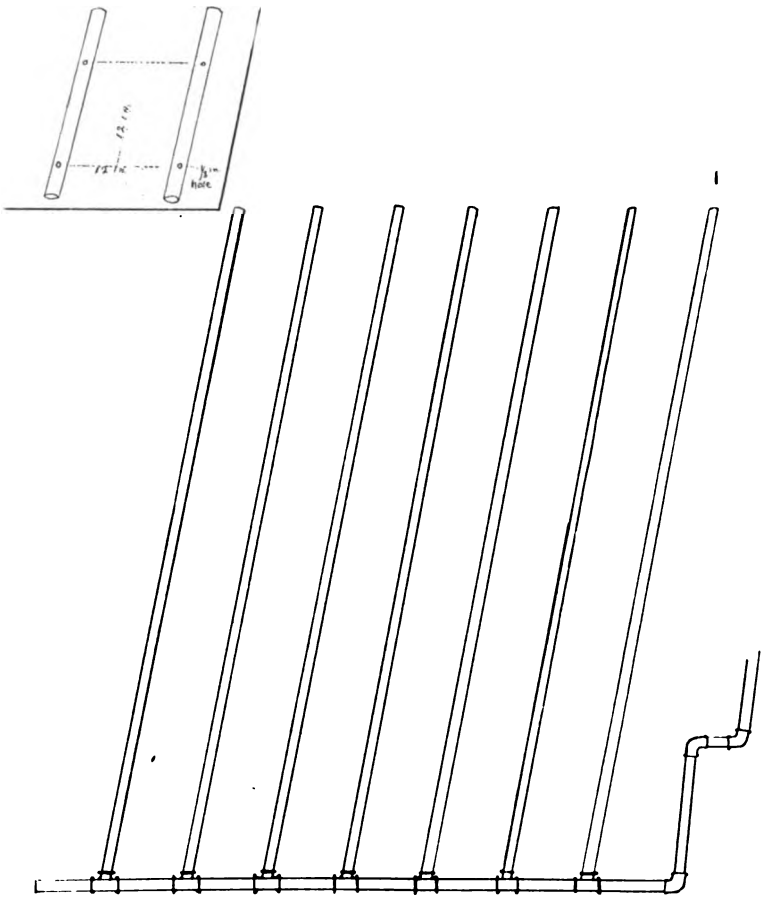
THE PERFORATED PIPE METHOD

This method of soil sterilization consists in a system of perforated pipes of convenient length to handle, about thirty feet, plugged at one end. The opposite end is connected to crossheads with high pressure boiler connection. The pipes should be about twelve inches apart. The holes may be one-eighth or three-sixteenths inch in diameter, placed on line about twelve inches apart and on the under side of the pipes when they are in position. The most serviceable size pipe is one and one-half inch and the crosshead and boiler connection two inches. The number of pipes in a system will depend upon the width of beds to be treated.

Where time and labor are important items two sets of sterilizing pipes or systems should be provided. This will allow one section of the bed to be sterilized while the second system is being placed in position. Both labor and fuel will be saved by using double or triple system. One set of pipes will cost ten or fifteen dollars.

The pipes should be buried to a depth of four to six inches and evenly covered over with soil. Less steam will be needed and time saved if the surface of the bed to be sterlized is covered over with burlap or canvas.

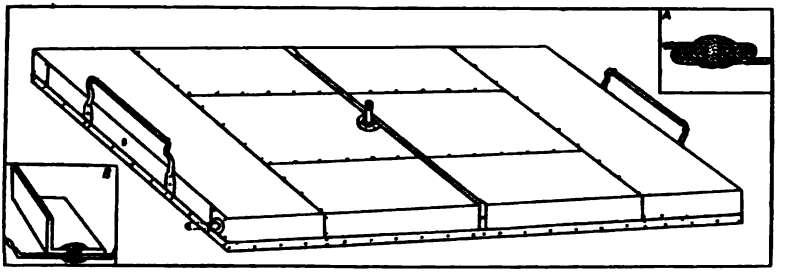
For best results the temperature should be raised to one hundred eighty to two hundred twelve degrees Fahrenheit, and maintained for an hour or longer. The time required to raise the temperature to this point will depend upon the size of boiler pressure, and amount of moisture in the soil.



PIPE SYSTEM FOR SOIL STERILIZATION
(Cir. 151, Ohio Agr. Exp. Sta.)

THE INVERTED PAN METHOD

The inverted pan method of soil sterilization as the name implies, consists in using a pan made of twenty or twenty-two gauge galvanized sheet iron, six inches deep and six to ten feet in size. This is inverted over the soil to be sterilized and steam is admitted through an opening in the top. Handles may be attached to the sides to facilitate moving. The steam is admitted and a pressure of eighty to one hundred pounds is kept up for about one hour. At this pressure a temperature of one



INVERTED PAN METHOD FOR SOIL STERILIZATION

The above drawing illustrates an inverted pan 6x10 ft. by 6-in. deep, made of 5 strips of galvanized iron with nipple for hose attachment to admit steam at top; construction lines at end indicate where steam is sometimes admitted, the inlet always to terminate in T form for dispersal of steam. The lower rim is stiffened by a continuous strap of 2-in. x 1-8-in. iron riveted to the lower edge of the pan. At end are shown handles riveted to this stiffner and projecting above the top of the pan. Where this projection is objectional iron pipe handles may be used with nipple base attached in the usual manner. Weight of such a pan probably less than 200 pounds.

Insert "A" shows details of folded double seam joint used in connecting the sheet iron.

Insert "B" gives details of attachment of angle iron across middle of pan; at each side this angle iron is bent over and bolted or riveted to the iron strap above described as facing the lower edge of the pan.

(Cir. 151, Ohio Agr. Exp. Sta.)

hundred eighty to two hundred degreesFahrenheit can be maintained. The edges of the pan are sharp, so that it may be readily sunk in the soil to a depth of three or four inches. If the ground is hard a tunnel will need to be made and the sides of the pan banked up after it is in place. A pan of the specifications named above will weigh from two hundred to three hundred pounds and will cost about fifteen dollars. One should be supplied with two or more pans so as only a minimum amount of time and steam will be wasted.

FORMALDEHYDE TREATMENT

Soil to be treated with formaldehyde should first be manured and prepared for planting. Some growers prefer to manure the beds after the drenching is done, but this is not considered good practice, as the manure may bring in a start of some of the fungi that the treatment is designed to destroy. A solution of one gallon of forty per cent formaldehyde to one hundred gallons of water is now considered to be the most effective. This should be sprinkled on the ground at the rate of one half gallon of the drench to each square foot of bed surface. The formaldehyde may be applied with a sprinkling can or a force pump with hose and nozzle. After the drenching the beds should be covered with a canvas or other material for twenty-four hours to retain the formaldehyde fumes. Providing the beds are to be planted within a few days, the soil should be turned two or three times after the covers are removed to allow the fumes to escape. The soil should be left open a week or ten days before being planted to a crop.

According to Mr. J. G. Humbert, of the Ohio Agricultural Experimental Station, Wooster, Ohio (Circular No. 151) the relative cost of different methods of soil sterilization are as follows:

"Estimating that pans and pipes last five years, that labor costs $2.00 per day, coal $3.50 per ton, and that ten houses are sterilized every year, it will cost to treat one house 30x100 feet (3,000 square feet in area) approximately as follows:

By Perforated Pipe Method—

Charge for depreciation of system per house per year	$ 0.40
Fuel, two tons of coal at $3.50 per ton	7.00
Labor, two men one day	8.00
	$15.40

By Inverted Pan Method—

Charge for depreciation of pans per house per year	$1.20
Fuel, two tons of coal at $3.50 per ton	7.00
Labor, two men one day	4.00
	$12.20

By Formaldehyde Drench Method—

Material only to drench one house	$21.00"

EFFECT OF STERILIZATION UPON THE SOIL

Steam sterilization has been found to loosen the soil materially, allowing surface water to percolate downward more rapidly then unsterilized soil, resulting in more rapid drying out of the upper layers of the beds. This will necessitate the beds being watered more often than otherwise. This form of soil sterilization has at least one advantage over the formaldehyde drench method, in that the high temperature kills all the weed seeds in the treated soil. Heavy clay soils may be injured by the heating process, but the ordinary bed or bench soil will not be injured by either form of treatment.

OTHER SUGGESTIONS FOR BED TREATMENT

Propagating beds located in fields or other open ground may be changed each year or so, and will not need any additional treatment. Some growers follow the practice of burning a brush heap on the bed area. This is a good practice as it kills some weed seeds and probably some fungi, and in addition the residue of ash left makes an excellent plant food.

The writer has observed that many growers, especially those growing tomatoes, allow the unused plants to grow in the beds during the summer. Such plants will almost invariably become diseased. The dead diseased parts will fall to the ground, be broken up and ultimately mixed with the soil and be a source of infection the next year. Destroy all unused plants as soon as the fields are planted. Also keep all weeds out during the summer, and the labor of weeding in the seedling beds will be greatly reduced.

BEE INSPECTION

The importance of the bee inspection work, which has been done in Indiana by this office, cannot be over estimated. A comparison of conditions this year with those of six years ago shows Indiana coming rapidly to the front as a progressive bee keeping state. There are some states where more honey is produced and more hives of bees kept; but none where the quality of honey can be surpassed or even equalled, or where more progress has been made in the science of bee keeping. The interest in apiculture can be seen in the comparative scarcity of the old style box hive or "Bee Gum", for the bee keeper of today realizes that only in careful scientific handling of his hives can he hope for the best returns from his efforts.

The value of the information given to the bee keepers by inspectors on their trips for the inspection of foul brood is now being shown in the increased yield of honey and the awakened interest. We no longer hear people say, "I tell you it won't be long till all the bees are dead". Seven years ago we heard that statement hundreds of times, but now, scarcely ever.

The fact that bees bring in a monetary return, which would otherwise be entirely lost, should not be forgotten. Even though the Indiana bee keepers only sell from $200,000.00 to $400,000.00 worth of honey each year (which is a low estimate), we should remember that this is the least of the good they do. Their real value lies in their worth as pollen distributors. It would indeed be a calamity if bee diseases were allowed to run their course and exterminate the honey bee. Millions would be lost yearly in all lines of agriculture if such a condition were allowed to develop. The fruit growers are beginning to realize the importance of the honey bee, and some are now keeping bees in their orchards for that express purpose, and are securing greater returns by making pollination reasonably sure. The truck gardeners now place hives of bees in green houses in winter where cucumbers, tomatoes and like crops are raised, so as to secure pollination and thus insure the blooms being fertilized. Each year we place more dependence upon the honey bee. As there are fewer wild bees and other insects which formerly did this work, growers are now using the honey bee in their place.

8286—7

REPORT OF THE STATE INSPECTOR OF APIARIES

The season just passed has in some repsects been very favorable to the beekeepers. The copious rains of 1915 were favorable to the growth of white clover in all parts of the state, but continued cold weather and rain last spring made honey prospects quite poor. With the advent of seasonable weather the bees built up quickly and a good crop of clover honey was harvested. The fall crop of honey was short, partly on account of the frost in the middle of September, and partly because of unseasonable weather.

In the parts of the State where no work has been done, there is very little difference in the disease conditions of the bees. In these localities American and European foul brood still continue to make inroads in the apiaries, due to ignorance on the part of most of the bee-keepers, who do not know the deadly nature of these diseases. However, in the districts where inspections have been made, and demonstrations for the treatment of brood diseases have been given, a decided improvement has been noticed. To the man experienced in the treatment of foul brood these diseases are not feared to the extent that they were a few years ago. He knows that he can keep his bees comparatively free from this trouble, with a reasonable amount of vigilance, even though there is foul brood in the neighborhood A bee disease said to be Nosema apis has been found in several parts of the United States, but thus far it has not appeared in Indiana. This disease is said to be extremely virulent, and it is well for every beekeeper to watch carefully the condition of the bees and report promptly to this office any unfamiliar disease that may appear. The following is a summary of the inspection work done by this office during the season of 1916:

Number of apiaries visited	204
Number of colonies inspected	3,308
Number of cases of European foul brood found	96
Number of cases of American foul brood found	440
Number of cases of Pickled brood found	81
Number of cases of Paralysis found	4
Number of box hives found	143
Number of crossed comb frame hives found	293
Number of movable frame hives found	2,872

The work of the year was largely done in the American foul brood regions. The amount of American foul brood found was

about normal. The percent of European foul brood found was much below normal, and is explained partly because of the gradual dying out of the disease because of the introduction of Italian stock, and also because most of the work of the season was done in localities where there has been in the past very little European foul brood.

In the above table it is shown that over four per cent of the hives inspected were box hives. This per cent is smaller than has been found in years past, and shows a very desirable tendency on the part of the beekeepers. However, there are nearly ten per cent of the movable frame hives that are crossed-combed. This condition makes a good movable frame hive virtually a box hive for the chief purpose of the hive has been defeated. Every beekeeper should use foundation the full length of the frames and see that the hive stands level. Even if only a one-inch strip of foundation is used, if the hive is level the beekeeper may be reasonably sure of having straight combs.

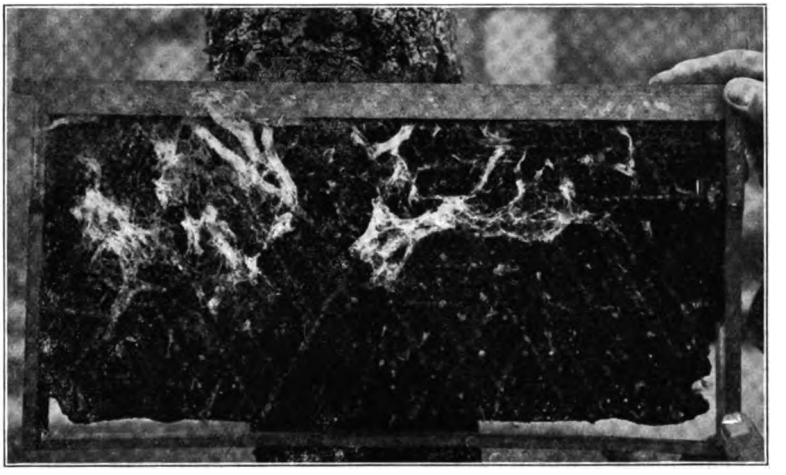
The same methods are still used in the treatment of American foul brood as have been recommended in previous reports, namely, the McEvoy Treatment. During the past year we have been practicing a slight variation, although it does not in any way involve any change in the principle. We strongly recommend the double treatment as was always insisted upon by the originator, Mr. McEvoy of Canada. Instead of shaking the bees first on frames with narrow starters, we now use no frames at all for the first shaking. In the three days following the shaking the bees may build a small piece of comb fastening it usually to the super cover that should always be placed under the cover when shaking. When ready for the second shaking, all that there is to do is to lift the super cover and shake the adhering bees into the bottom of the hive. Then the frames with full sheets of foundation may be set in the hive. The small piece of comb can easily be scraped off the super cover with a hive tool and the cover replaced. This slight variation of the McEvoy treatment saves the using and destroying of the small pieces of foundation; saves the disinfecting of the frames and removes any temptation on the part of the beekeeper to take chances on a single shaking treatment and the use of full sheets of foundation insures straight combs free from drone comb.

Some beekeepers still prefer the shaking treatment for European foul brood. While the shaking treatment is quicker and urer in very severe cases, yet almost any incipient case can be

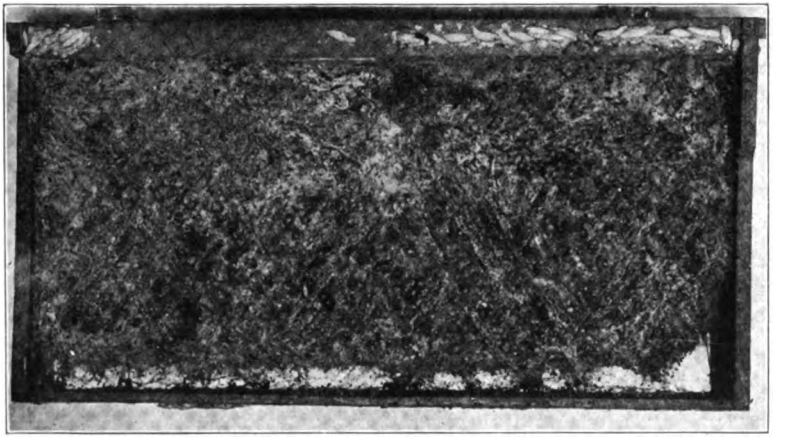
cured by de-queening and re-queening in three weeks with vigorous Italian stock. Immunity can be secured only by re-queening with the best Italian queens and then conscientiously weeding out any queen that shows her inability to combat the disease. It is useless to try to cure the disease in weak colonies. Weak colonies must be doubled together until a strong colony is formed.

The Bureau of Entomology of the United States Department of Agriculture has issued two bulletins which everyone should secure if possible. They are Department Bulletins No. 93, "The Temperature of the Honey Bee Cluster in Winter" and Farmers Bulletin No. 695 "Outdoor Wintering of Bees". These two bulletins should impress every beekeeper with the fact that in order to secure the best results the bees must be protected during the winter. Various methods of protection have been discussed in Bulletin No. 2 of this office, entitled "Information for Beekeepers". For a further discussion of this subject the reader is referred to this bulletin which is free for distribution in Indiana. Beekeepers in Southern Indiana should not be misled because of the more moderate temperatures, in the winter time. Even along the Ohio River colonies should have at least a shallow super full of packing above them during the winter. Investigations tend to show that packing around the colony is desirable in some localities even in the summer time. The loss of bees is mostly due to exposure during the winter, lack of food, unsuitable food, disease or spring dwindling. If live stock farmers would suffer the same percentage of loss per year that beekeepers ordinarily suffer, their business would soon fail. Beekeepers seem to expect to lose a considerable number of their colonies each season. There is no good reason why the beekeepers loss should be much larger than the stock raisers loss. If the stock raisers would house and care for their stock in as careless a manner as many beekeepers care for their bees, their losses would be enormous. Because bees are able by nature to so care for themselves that many of them survive the winter is no justification for any beekeeper not to provide sufficient protection and food. Because of poor wintering, a large percent of the colonies in the State are not strong enough to store comb honey until the comb honey season is nearly over. When colonies come through the winter in a weakened condition, it is advisable to double two or more together. This will insure one colony strong enough to store a surplus. It is an extremely dangerous practice to attempt to winter diseased colonies. The death of the queen

or some other misfortune may leave them the prey of robbers and thus cause the disease to be scattered far and wide. If disease is discovered too late in the fall for treatment, such colonies should



BROOD FRAME SHOWING THE SILK LINED TUNNELS CONSTRUCTED BY THE LARVAE OF THE BEE MOTH



THE SAME FRAMES SEVERAL WEEKS LATER

The wax has been almost entirely eaten away and the larvae are in the white cocoons, some of which can be seen on the top bar of the frame

be moved out of the yard to a place as far distant from any bees as possible and wintered there. This will insure the least danger of spread of the disease. European foul brood attacks weak colonies

especially. Where this disease is known to be present the beekeeper must be very vigilant in the spring time, lest the disease gets beyond his control.

It has been very noticeable to the inspectors that most beekeepers waste a considerable amount of comb. Waste comb varies greatly in the amount of wax that it contains. New comb may contain almost one hundred per cent of wax while very old combs contain proportionately less according to the amount of dirt, cocoons and pollen that they may contain. At the present price of wax, it is very probable that several thousand dollars worth of wax goes to waste every year in Indiana. A little more care in saving old combs and in gathering up the scraps of wax would add considerably to the income of some beekeepers, but more important than the financial returns is the elimination of the danger of spreading disease through scraps of comb containing infected honey. If one does not desire to render the wax, it may be stored until sufficient accumulates to justify shipping to someone who makes a business of rendering. The ordinary methods of rendering leave from five to fifty per cent of the wax in the refuse, and so, for most beekeepers it is more profitable to ship the combs for rendering.

Increase is almost always made at the expense of all or part of the honey crop. In some favored localities in Indiana the principal honey flow comes so late in the season that neuclei made early in the season can be built up into strong colonies in time to store a maximum crop. Most of the extensive beekeepers in Indiana agree that they can buy their increase cheaper than they can produce it. The only noticeable exceptions to this statement are those beekeepers situated in the extreme southern part of the State and who are favored with a very early flow from maple, locust, mustard and other plants. In this region increase can be made profitably and it is quite likely that a considerable business of furnishing increase for northern beekeepers will be built up as beekeepers become more familiar with the combless package of bees. As an insurance against disease, it is generally profitable to buy up as many as possible of the small lots of bees kept by neighbors who make no pretense of being beekeepers. Usually these bees can be secured more cheaply than from any other source. In common with other foods the price of honey is somewhat higher this year than last. It is to be hoped that beekeepers will hold this advance in price, because in many parts of the State

Indiana honey has been retailing at ridiculously low prices. Too many producers have been retailing at wholesale prices or slightly above. There is no justification for such unprofitable and unbusinesslike methods. Every Indiana community offers an opportunity for the sale of large quantities of Indiana honey. There is no necessity of seeking a market outside of the State. The consumption in Indiana is far beyond the production. Many producers are shipping honey to jobbers outside of the State who repack or bottle the honey and return it to Indiana merchants at from twenty-five to one hundred per cent more that the Indiana producer received for it. This condition is not for the best interests of Indiana beekeepers and can be remedied only by them. The beekeepers should develop their home market to the limit. The home market will pay a higher net profit than any outside market. The beekeeper who does not like to sell honey from house to house can very profitably advertise and bring the trade to him. It is surprising how much greater is the demand for home grown honey than for honey that is shipped in by professional packers. A trifle spent for advertising will make any beekeeper known as the "Honey Man" throughout his county. Many Indiana beekeepers sell their own crop at home and then buy several times as much as they produce in order to take care of the demands of the home market which they have created.

Only a small per cent of the nectar produced in Indiana is ever gathered by the bees. Every part of the State from the sand dunes on the north to the Ohio River on the south has many nectar producing plants. Indiana honey production can be doubled several times without over-crowding. There are many very desirable locations practically unoccupied. Every county in the State produces some high grade honey. Very few counties produce any amount of honey of very inferior grade. Recent books on beekeeping by Dr. E. F. Phillips, of the U. S. Department of Agriculture, and by Frank C. Pellet, State Inspector for Iowa, point out the profitableness of honey production as compared with general farming. To secure a net average income of one hundred dollars from bees does not require nearly so high a capitalization as is required on the average in other lines of farming to produce the same income. Another advantage is that one may begin with only a few dollars of capital and gradually increase.

This phase of the matter appeals especially to the suburban residents of our cities who are desirous of gradually developing

some line of agricultural pursuit. It has been rightly observed that a large part of the professional beekeepers of the future are now suburbanites.

The State Board of Agriculture has very appropriately recog nized the importance of the bee industry by increasing their appropriation for premiums on bees, honey, wax, honey vinegar and beekeeping appliances. The exhibit this year was confined to less than half a dozen exhibitors. The small number exhibit ing was doubtless due to beekeepers not knowing of the additional appropriation. It is to be hoped that the State Board will not be discouraged by the small showing of this year but will continue the same premium list for another year. Every beekeeper who can show a case of comb honey or a dozen or more bottles of extracted honey ought to show his appreciation of the recognition given the beekeeping industry by making a special effort to furnish at least a small exhibit for the State Fair. It is one of the cheapest forms of publicity that can be secured.

SOME OF THE IMPORTANT INSECT PESTS OF INDIANA.

By R. E. SNODGRASS

There are so many different kinds of insects and so many individuals of each kind that it would be very hard for them all to find a living in the world if it were not for the fact that they are adapted to live in such a great variety of ways. It would seem that there is scarcely a nook in the whole vegetable kingdom that does not in some way support an insect. For this reason the agriculturist finds himself beset on every side by a great number and variety of insect pests, and the multitude of ways in which they live and derive their existence from his crops compel him to fight these enemies by almost as many different means as there are varieties of them. However, the control of insect pests depends largely on a knowledge of how they eat, and from a feeding standpoint they may be divided into two groups. Those of the first group bite off, chew and swallow bits of the leaves or whatever else they feed on; while those of the second group puncture the surface of the leaves and stems and suck out the sap. It is obvious that pests of the first sort may be killed by spreading some kind of poison evenly over the food plants which the insects will swallow along with their meals and thus be killed. This method, however, would not work at all with the members of the second class, for they are provided with piercing and sucking organs which enable them to draw up the sap from beneath the surface, and poison on the latter would in no way effect them. Such as these, therefore, must be destroyed by spraying some substance directly on the pests which will kill them just by coming in contact with their bodies.

Thus we have the class of *biting and chewing insects* and the class of *piercing and sucking insects*. So, likewise, we have two corresponding groups of insect poisons or insecticides—the *stomach poisons* for the first class, and the *contact poisons* for the second class. Hence, there is a perfectly simple and logical reason for treating one pest with arsenate of lead, for example, and another with lime-sulfur, kerosene or a nicotine solution. All insects could be killed by one or the other of these poisons if they could all be gotten at, but many have the habit of hiding themselves in crevices or in flowers or in other places where they cannot be reached with either a solid or a liquid poison. Such as these must be killed by fumigation with a poisonous gas. So,

we must add a third group of insecticides—the fumigants. Of course there are various other methods in practice for the destruction of insect pests than the use of chemical insecticides, such as trapping them and the generation of high temperatures in infested rooms and buildings. All insects, too, do not come under the two classes mentioned, for some have sucking but not piercing mouth organs and can feed only on exposed liquids, but these can be killed with stomach poisons in liquid form.

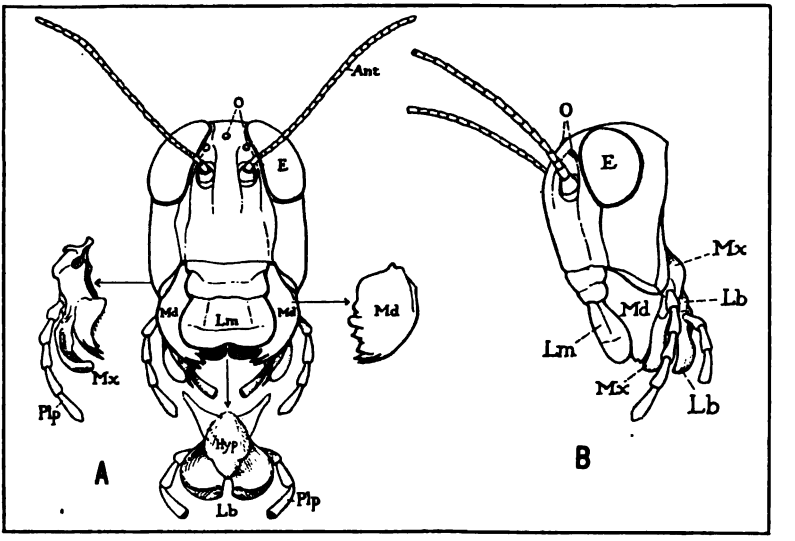


Fig. 1.—HEAD OF A GRASSHOPPER, ENLARGED SIX TIMES

A, front view, showing the antennæ (*Ant*), the two large eyes (*E*), the three small eyes or ocelli (*O*), and the mouth-parts at the lower end of the head. *Lm* is the upper lip or labrum, behind which are the biting jaws or mandibles (*Md*), working sidewise, one of which is shown separated at the right. Behind the mandibles is the second pair of jaws, the maxillæ (*Mx*) one of which is shown separately at the left. Behind the maxillæ is the lower lip or labium (*Lb*) shown separately below; *Plp*, the palpus.

B, The same in side view.

A common insect of the biting type which feeds on solid food is the ordinary grasshopper. If you will examine the head of one you will see at the lower end of it and at the sides of the mouth a pair of large, strong jaws (fig. 1, A, *Md*). These jaws are called the mandibles. It will be seen that they work sideways and not up and down as do our own. Each has a number of strong teeth on its inner cutting edge as shown in the one drawn separately at the right. In front of the mandibles is a large upper lip (*Lm*) called the labrum.

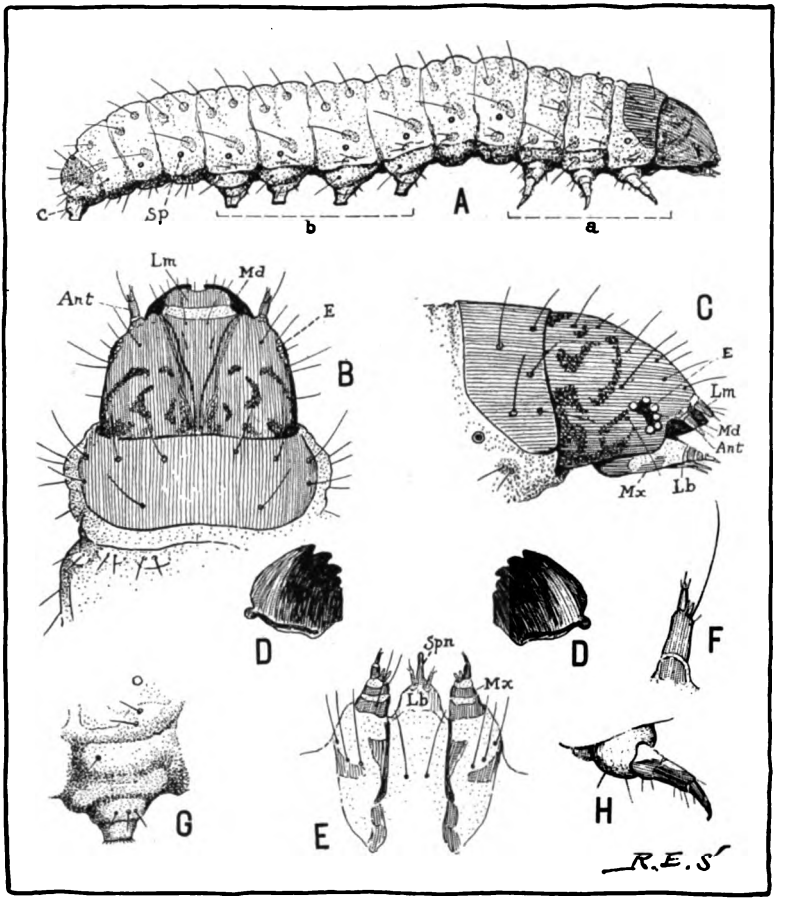


Fig. 2.—THE CODLING MOTH LARVA, GREATLY ENLARGED

Example of an insect that feeds by eating portions of the plant or fruit on which it lives, not simply by sucking the juice. It is provided with a pair of strong jaws for biting and chewing, and all such insects may be killed by spraying the food plant with arsenate of lead or some other stomach poison.

A, side view of the full grown worm or larva: *a*, the thoracic legs which become the legs of the moth; *b* and *c*, the abdominal legs or prolegs which are not present in the moth stage; *Sp*, one of the row of breathing pores or spiracles along the side of the body.

B, top view of the head and first body segment: showing the upper lip (*Lm*), the jaws called mandibles (*M*), which work sideways, projecting from beneath it, the small antennæ (*Ant*), and the group of simple eyes (*E*), on the side of the head.

C, side view of the head and first body segment: lettering same as on B, but here is shown the large under lip which is composed of three parts, shown separate at E, of which the side pieces (*Mx*) represent the maxillæ of the grasshopper (fig. 1) and the middle one (*Lb*) the labium; on the tip of the latter is a hollow spine (*Spn*), the spinneret, from which issues the silk used by the mature larva in spinning its cocoon.

D, D, the jaws or mandibles separated from the head.

E, the under lip formed by the combined maxillæ (*Mx*) and the labium (*Lb*), *Spn*, the spinneret.

F, one of the antennæ (*Ant* on B and C).

G, one of the prolegs of the abdomen (*b* on A.)

H, one of the thoracic legs (*a* on A).

Just back of the mandibles is another pair of mouth appendages, one of which (*Mx*) is shown separated from the head at the left in the figure. These are called the *maxillæ* (singular, *maxilla*). Each has two terminal divisions; one with three sharp teeth, the other forming a hood-like affair fitting against the outer side of the toothed one; and a five jointed feeler called the *palpus* (*Plp*) attached to the side. Figure 1, B gives a side view of the head showing the labrum (*Lm*), the mandible (*Md*), the maxilla (*Mx*) and another appendage (*Lb*) which forms an under lip behind the maxillæ. This is called the *labium*. It is shown separated from the head below in A, where it is seen to consist of a basal part carrying two large terminal lobes and a three-jointed palpus (*Plp*) on each side. On its front or upper surface is a thick pad (*Hyp*) forming the tongue, called in insects the *hypopharynx*. All of these mouth appendages together are called the *mouth-parts*. Nearly all insects have mouth-parts corresponding with those of the grasshopper, though in some they look very different on account of being changed in form to suit to the different ways that various insects feed.

For example, in figure 2 is shown the larva of the codling moth or the worm that infests apples. This is also an insect of the biting class, and at B, which represents the top of the head, the mandibles (*Md*) are seen projecting beyond the upper lip (*Lm*). They are very similar to those of the grasshopper and are shown separately at D and D. A side view of the head is given at C, where the labrum (*Lm*), the mandible (*Md*), the maxilla (*Mx*) and the labium (*Lb*) are all shown, but the last two parts will be seen at once to be quite different from those of the grasshopper. They are shown separated from the head at E where it may be observed that the three are partly grown together and that all their parts are very much reduced and simplified. For some reason the apple worm does not need such complicated maxillae and a labium as does the grasshopper. The spine (*Spn*) on the labium is the *spinneret* from which the worm spins the silken threads for making its cocoon.

But both these insects are of the biting mouth-part variety and may be killed by a stomach poison put on their food. Others of the same class are cockroaches, crickets, beetles and all caterpillars such as the cutworms, the cankerworms, the army-worms, etc.

Now, if we examine the mouth-parts of a plant louse or

aphis (fig. 3, A) we find something which at first sight looks entirely different from the mouth-parts of the other two insects.

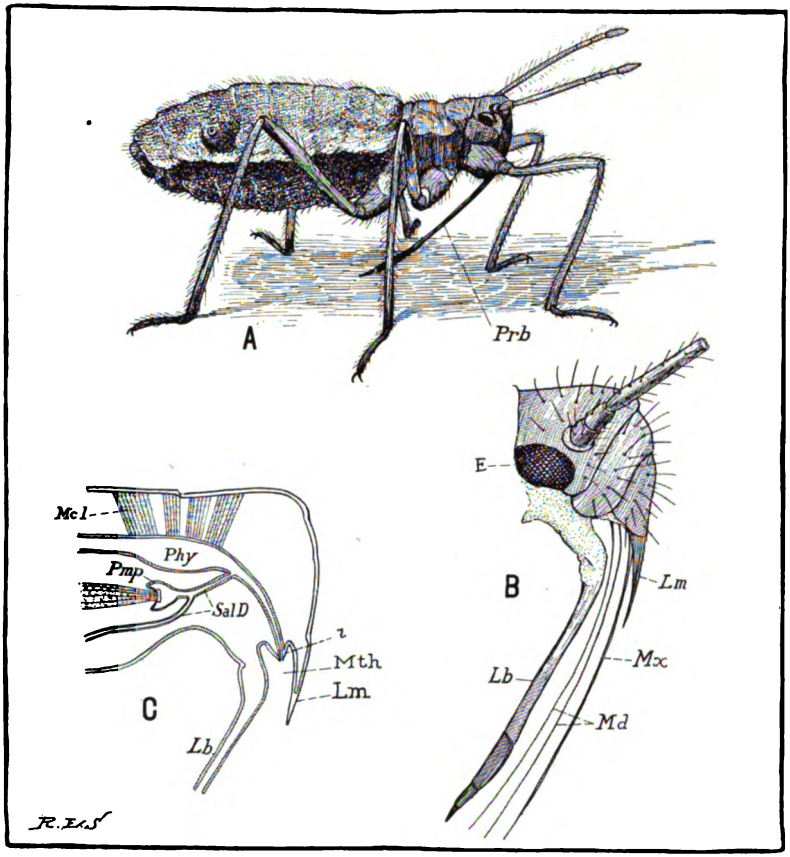


Fig. 3.—AN APHIS OR PLANT LOUSE, GREATLY ENGLARGED

Example of an insect that feeds by sucking the sap from the plant on which it lives by means of a long beak or proboscis (A, *Prb*) that it thrusts beneath the surface of the leaf, twig or fruit. Such insects must be killed by a contact poison like lime-sulfur, nicotine sulphate or kersoene.

A, the entire insect, showing the proboscis (*Prb*). (Magnified about 25 times.)

B, head with parts of the proboscis separated to show its structure: *Lb* is the labium which is grooved in front and contains the bristle-like mandibles (*Md*) used for piercing, and the maxillæ (*Mx*) which are united to each other to form a tube for sucking up the sap from the puncture; *Lm* is the upper lip or labrum; *E* is the eye. (Greatly enlarged.)

C, vertical median section of the head showing the mouth cavity (*Mth*) into which the pharynx (*Phy*) opens at the tip of a little cone (*i*) that fits closely between the bases of the maxillæ which are removed in the section; *Phy* is the prarynx or throat which is worked like a syringe by the muscles (*Mcl*) to draw the sap up into the mouth. (Greatly enlarged).

Some sucking insects, especially those that bite man and animals, inject a poisonous saliva into the wound made by the beak by means of a force pump (*Pmp*) connected with the salivary duct (*Sal D*).

Extending downward and backward from the lower part of the head is a long, slender sharp-pointed beak or *proboscis* (*Prb*). The aphis belongs to the piercing and sucking group of insects. A closer examination of its beak shows that there is a deep groove all along its front edge in which are contained four slender rods. These rods are shown separated from the groove at B. There appears to be only three of them, but two are adhering closely to each other except at their bases. These four rods represent the mandibles (*Md*) and the maxillæ (*Mx*) of the grasshopper's mouth-parts, and the body of the beak is the labium (*Lb*). A labrum (*Lm*) also is present and fits down close over the basal part of the groove in the labium. Here, then, all the parts are modified into very different forms to produce a piercing and sucking apparatus, but they are the same organs as those of the grasshopper after all.

The slender rod-like mandibles and maxillæ are held in the groove of the labium while, by means of muscles attached to their bases, they are made to pierce the surface of a leaf or twig. Then the sap is sucked up through a minute tube formed by grooves in the opposing edges of the closely united maxillæ. The sucking is of course done by the throat or pharynx (C, *Phy*) which has muscles (*Mcl*) attached to its walls that make it expand like a bulb, while others within its walls make it contract again. The mouth cavity (*Mth*) is the space between the bases of the labrum and labium while the pharynx opens into it on the tip of a little cone (*i*) which projects between the bases of the maxillary rods. Thus the liquid ascending between the latter passes without interruption into the throat. (Figure 3, C being a median section, its plane lies just between the rods, so the latter are not shown).

Other insects that have sucking mouth-parts of this sort are the scale insects, cicadas, leaf-hoppers, squash-bugs, bedbugs, electric light bugs and other relatives of these. Some of them have a posionous saliva that they can inject into the wound made by the piercing rods, which causes a swelling or congestion and produces a greater flow of sap or blood for them to feed on. The assassin bug is one of this class and its bite is very painful. The poison is pumped out of the mouth through the beak and into the wound by a special salivary pump (C, *Pmp*) connected with the salivary duct (*Sal D*).

All of these insects which attack plants must be killed with a contact insecticide or by fumigation. No successful method has

been devised for innoculating a plant so as to poison its sap without injuring the plant itself.

Everybody knows that a butterfly comes from a caterpillar and a fly from a maggot, but so likewise, is it true that nearly every insect is different in its younger stages from the form of the adult—none but a few very simple ones change only in size during growth. The rest undergo a series of changes in structure, some very radical, others comparatively slight, but whatever the degree of change, it is called *metamorphosis*. This is a long word but it is simply Greek for "change of form."

Every insect originates in an egg but the forms that hatch from the eggs present more outward difference than the adults themselves. In some cases, like that of the grasshopper, shown at the top of figure 4, the young insect has the parent form and is known at once to be a young grasshopper. It grows into the adult by a series of slight changes, and such metamorphosis is called simple or *incomplete metamorphosis*. In the first stage there are no wings and the head is very large. In the next stage very small wings have sprouted and the body is larger in proportion to the head. In the next stage and the next, and so on, the wings lengthen and the other parts assume adult proportions and shape till at last the final mature stage is reached. Only two of these immature stages are figured for lack of space.

Now, at the end of each stage in its growth the young grasshopper sheds its skin, and this skin-shedding process is called *moulting*. Whenever the insect is ready to moult the skin splits down the back and the creature comes out in a brand-new skin that has formed inside of the old one, and the newly emerged creature is all of a sudden decidedly more like its parent. It is not only larger but its wings are longer and altogether it has much more of a grasshopper appearance. After the new skin is dry it does not change any further till the next moult, when it emerges again yet more like the adult, and so on. However, what appear to be sudden changes are really not such, for during each stage the creature has been changing gradually inside of its outer skin while forming the new one within, and it is only when it sheds the former that the result of these changes can be seen.

The stages which a young insect passes through in its growth are sometimes called *instars*, and the immature individuals of insects with incomplete methamorphosis are called *nymphs*, but the word *larva* is used in a general sense for the young of all insects.

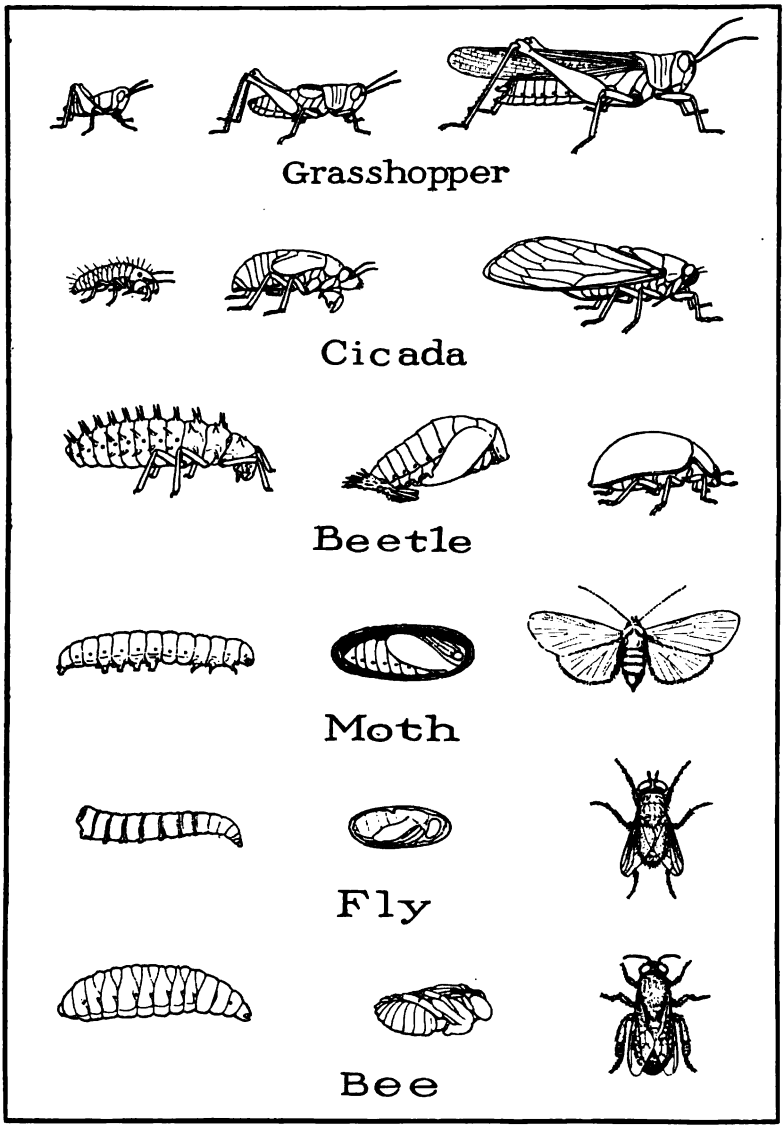


Fig. 4.—METAMORPHOSIS

Examples of the different ways in which insects change in their growth from the young to the adult. The grasshopper grows by easy stages from a young grasshopper to the adult; the cicada does the same but the changes are greater; the beetle, the moth, the fly and the bee, however, go into a resting stage or pupa after the young or larva is full grown before transforming into the adult. The beetle has a naked pupa; the moth caterpillar spins a silken cocoon about itself; the fly maggot transforms within its own dried skin; the bee lies in a waxen cell constructed by its older sisters.

In the next example given in figure 4, the cicada, the newly-hatched nymph looks more different from the adult than the young grasshopper does, but still it grows into the adult by a series of moults in which there is a gradual approach to the parent form.

In the third example, however, which represents one of the lady-bird beetles, the young is a totally different-looking creature from its parent, and in its successive moultings it does not get any closer to the adult. That is, not till the next to the last moult, when it suddenly makes a very great change and becomes a creature with wings and other parts resembling those of the adult, but having both wings and legs bound close to the body; and thus it remains inactive till finally it undergoes the last moult and the perfect beetle emerges. Here, then, we have an example of a more pronounced degree of metamorphosis, which is called *complete metamorphosis* since it involves a succession of distinctly different forms. These are called the *larva*, the *pupa* and the *adult* or *imago*, the pupa being the resting stage between the last and next to the last moults. All the higher insects go through these stages in their metamorphosis. A familiar example, shown next in figure 4, is that of a moth, the larva of which is the worm-like creature called a *caterpillar*, while the pupa is a hard-shelled thing called a *chrysalis*. Before changing to a pupa the caterpillar spins a cocoon of silk all around itself from silk glands opening on its lower lip, and the chrysalis lies almost motionless on its back inside of this till it is ready to transform into the moth. The latter then must push its way through the end of the cocoon in order to emerge.

In the house fly, shown in the next line, the larva is a legless *maggot*. When it is full grown the last skin does not split open but dries into a hard capsule-like shell inside of which the pupa is formed. This capsule is called the *puparium*, and the adult fly in emerging has to push off the end of it to escape.

The honey bee is given as the last example of the varieties and degrees in insect metamorphosis. The bee larva is a big, fat, helpless *grub* utterly incapable of providing for itself. It spends all of its life in the honey-comb cell where it was born and where it is fed bee-jelly, honey and pollen by the adult nurse bees until it is full grown. Then it is sealed up and changes to a pupa. When it transforms to an adult it has to gnaw its way through the wax cap of the cell in order to come out into the hive.

Metamorphosis is to be explained as the result of an extreme division of labor between the young and the adult stages. Take

the moth for example: the caterpillar is a greedy creature, always hungry and always eating—in fact it lives to eat and makes no secret of it, for eating is its business in life—it eats so much that it almost relieves the moth of this time-wasting duty, for much of the products of the caterpillar's digestive work is stored up later as a fat in the moth's body. Therefore when the moth emerges it can devote almost all of its time and its energy to the mating function and the laying of eggs, sustaining itself sufficiently on a little nectar. Some adult insects scarcely eat anything, and a few fast entirely, even having no mouth-parts with which to eat if they had the desire. Such of course do not live very long, only long enough to accomplish the perpetuation of the species, and then they die. One species of cicada spends nearly seventeen years maturing underground, and then lives but a few weeks as an adult in the trees. The young may-flies live from one to three years in water and perish in a day or so after they emerge as free-flying adults.

The structural differences between the young and adult stages of insects are, then, apparently for the purpose of allowing the latter to devote as much time as possible to the reproductive functions, and the former to the growing or vegetative functions. The caterpillar, for example, is much better adapted for procuring food than a small moth-like creature would be. But, in the course of specialization, the two stages have become so very different that the resting pupa stage must intervene to enable the larva to get back to the parent form. Inside of the pupa a reconstruction process goes on. Many of the larval organs are now discarded entirely: the alimentary canal, the muscles, glands and other parts are absorbed and a new outfit is formed for the future adult, adapted to its special purpose. Therefore, it must not be assumed that the worm-like form of the larva of many insects means that insects have evolved from worms. The real worms are entirely different creatures with no relationship whatever to insect larvæ.

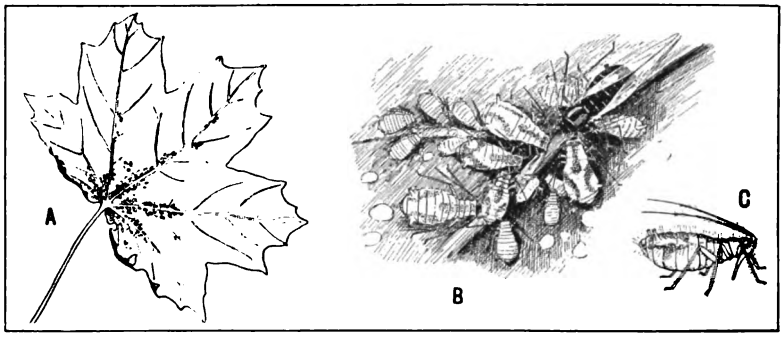


Fig. 5.—A COMMON APHIS ON MAPLES

The maple Chaitophorus (*Chaitophorus aceris*). A, group of the lice on under side of leaf. B, cluster of individuals enlarged, showing one winged form and wingless ones in various stages, surrounded by drops of honey dew. C. a single wingless individual, enlarged about 7 times.

APHIDS OR PLANT LICE.

These are the little bugs usually of a greenish color, though often yellowish or brownish and sometimes red or black, that occur so plentifully on the stems and foliage of plants and trees, but especially on the under sides of the leaves. They are common pests of the garden, infesting roses and other flowers, melons, tomatoes, cabbages and most every other kind of vegetable. They usually cause the leaves to turn yellow and then to curl and twist into fantastic shapes (fig. 6) that form pockets on the under sides in which the aphids collect often in great numbers. Other species infest shade trees and fruit trees (fig. 5). They all do much damage to the host plant, whenever they are present in considerable numbers, on account of the sap which they extract from the green parts; and they cause the leaves to die or to drop off, which may result in the death of the plant.

Fig. 6—TYPICAL PLANT LICE CURLING OF LEAVES

Most of the aphides excrete a clear, sweetish liquid from their

alimentary tracts which may gather on the surface of the leaves like a coating of syrup or varnish. This is called honey-dew. In itself it does no harm to the plant but a black fungus often grows in it which detracts from the appearance of a tree and lessens the market value of the fruit. Honey dew is much sought after by ants and attracts swarms of flies to the trees.

The sucking mouth-parts of the plant lice have already been described (see page 109 and fig. 3). Being piercing and sucking insects, feeding from beneath the surface of the leaves or stems, the aphids must be killed by a contact insecticide; and in spraying care must always be taken to apply the liquid directly to the insects themselves for only those individuals will be killed that get touched by the spray, and they will usually be most abundant on the under surfaces of the leaves.

At present the best known remedy for all plant lice is nicotine and the tobacco preparations of 40 per cent nicotine sulphate are the most widely recommended for general use. In general for plant lice a half pint of the nicotine solution should be used for every fifty gallons of water, to which about three pounds of a mild soap like ivory soap, or better still any kind of soft soap, dissolved in hot water, should be added. Kerosene emulsion used to be the standard remedy for aphids but its effect is not so certain as that of nicotine sulphate and it often produces injury to the plants.

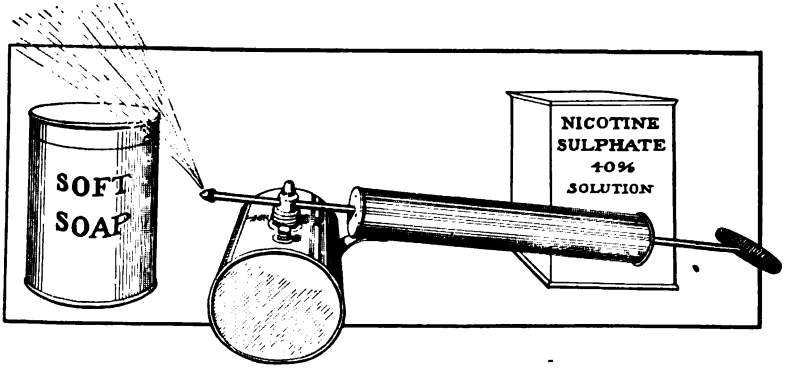


Fig. 7.—SIMPLE EQUIPMENT FOR TREATING PLANT LICE IN THE GARDEN. THE NOZZLE THROWING AN UPWARD STREAM GIVES AN EASY MEANS OF SPRAYING THE UNDER SURFACE OF THE LEAVES

For garden purposes a small hand sprayer may be used such as the one shown in figure 7 which has a nozzle that will throw

an upward spray. This is a great convenience for getting at the under sides of the leaves where the aphids on melons, tomatoes, cabbages, etc., are most likely to be. Such a sprayer holds a quart of spray liquid and will cost from seventy-five cents to a dollar and a quarter. A cheaper instrument that throws only a direct spray can be had for less, but the inconvenience of using such is scarcely worth the saving in price.

To make a quart of nicotine spray half a teaspoonful of the nicotine sulphate is enough, to which add a few chips of soap dissolved in a little hot water, or half a teaspoonful of gold dust. Most washing powders, however, are not soap and will be injurious to the plants if used in a spray mixture.

Everybody that cultivates roses in the garden is likely to be much annoyed by the lice that affect these plants in such great numbers. These are the rose aphids (fig. 8). They attack especially the tender growing shoots, the flower buds and the young leaves, checking the growth of the bush and destroying the flowers and leaves, often causing the latter to curl downward at the edges producing pockets on the under sides which afford protection to the pests. The rose aphids form much honey dew which makes a gummy coating over the leaves, and then a black fungus grows in it that mars the beauty of the plant.

Fig 8.—PLANT LICE ON ROSE STEMS
(From Photograph, Russell, U. S. D. A.)

A strong stream of water thrown on the bushes from the garden hose will dislodge many of the pests, but the best remedy for them is nicotine sulphate used as given above for garden crops.

Shade trees are often badly infested by aphids, especially the maple. Last summer a maple aphis called the maple *Chaitophorus* (fig. 5) caused much concern to the owners of maple trees, in Indianapolis particularly during the later part of June and the first of July. These pests congregate in large numbers on the under sides of the leaves near the base and they often excrete

so much honey dew that this liquid covers the backs of the leaves beneath and gives the entire tree a glistening, varnished appearance. Frequently it drips to the pavement and spreads out in large sticky patches under the trees. It does no harm itself, but its presence is a sure sign that the tree is badly infested with aphids. If the trees are being damaged the pests can be killed with nicotine sulphate, but usually the insects disappear after midsummer and do no greater harm than causing the trees to drop some of their leaves.

Elm trees are infested by the woolly elm aphis which makes conspicious, white, cottony masses on the limbs and smaller branches. The bodies of these insects are covered with a white, waxy secretion and when a large number of them are clustered on one spot they look like bunches of cotton on the trees. They can be controlled with nicotine sulphate, but the spraying must be repeated until all are killed, for they are usually so massed together that those on top protect the ones beneath.

Fig. 9.—APPLES DWARFED BY PLANT LICE.

On apples there are four species of aphids which are important pests. They are known as the green apple aphis, the grain or oat aphis, the rosy aphis, and the woolly apple aphis. The first three lay their eggs in the fall on the branches, twigs or trunks of the trees and the best precaution against their ravages in summer is to spray the eggs during the winter with lime-sulphur as used for the San Jose scale. Of course some of the eggs will escape destruction on account of being placed beneath the bark or in

other sheltered places, but if the spraying is thorough over all parts of the trees the pests are likely to be controlled to such an extent that spring and summer remedies will not be necessary.

If, however, the aphids are present and have not been killed in the egg stage by a winter spray, early in the spring two species, the green apple aphis and the grain aphis, will hatch out and immediately migrate in great numbers to the expanding buds (fig. 10). They should be sprayed at once. The New York Experiment Station recommends the use of forty percent nicotine sulphate; three-fourth of a pint to one-hundred gallons of water and about four pounds of dissolved soap as a sticker. But it will probably be safer to use a stronger solution than this, a half pint of noctine sulphate to fifty gallons of water. If lime-sulphur is being used at the same time for scales, the nicotine may be added to this spray without the soap.

Fig. 10.—Apple aphids attacking an opening apple fruit bud.

Later in the spring these two species and the rosy apple aphis will attack the leaves. As the season advances the leaves curl and the pests gather in the pockets on their under sides where it will be difficult to get at them. Therefore the spraying of the leaves should be done before the curling begins, using nicotine sulphate as on the buds.

The woolly apple aphis, so called because its body is covered with a white cottony excretion of wax, lives in clusters on both the twigs and the roots of the apple trees, but it lays its eggs on elms from which it migrates to the apple trees. Therefore, winter spraying on the latter will not effect this species. The twig colonies can be controlled in summer with nicotine sulphate.

The aphids have very interesting and often complicated life histories. It will generally be noticed that while most of the individuals seen during the summer are wingless, there are usually a few winged ones associated with them. These wingless ones are not always simply the immature forms, because most of them are capable of producing young. The winged individuals are migrating forms whose function is to spread the species from one plant or tree to another, either of the same or of a different kind, for many of the aphids divide their attention between two species of host plants, one called the primary and the other the alternating host. On the former the insects lay their eggs

in the fall and live a short time in the spring after hatching, then they fly away to the alternate host and live there during the summer, returning again in the fall to the first one. For example, there is the grain aphis, called also the oat aphis and known to entomologists as *Aphis avenæ*, which in the fall lays its eggs on apple and pear trees, especially in the axils of the buds, where the young hatch in the early spring and migrate in company with the young of the green apple aphis, to the expanding buds. Later they live for a while on the leaves and then the winged forms fly away to grains and grasses where the species lives during the summer, coming back agin to the apples and pears in the fall to lay the eggs.

But it is not one generation that does all this: usually a large number of generations follow each other in rapid succession from spring to fall, and all of these generations except the last consist entirely of females—females that are able without fertilization to give birth to living young. Many of these are wingless, as already described, living their short lives entirely on the plant on which they were born, while others are winged and fly from one plant to another. In the fall winged forms return to the primary host and there each gives birth to one young one, but these are males and females—the true sexual individuals that mate and produce the winter eggs in the usual fashion. The individuals of the first generation that hatch in the spring are called the "stem mothers" because they give rise to the long series of generations that intervenes before the males and females appear again.

Some of the wingless forms often remain on the alternate host indefinitely producing generation after generation of females that reproduce by the a sexual process. Thus there are two series of forms in many species, one that alternates from one host to the other and produces one generation of sexual individuals in the cycle, and another that continues on the alternate host as a sexual generations entirely.

In many of species some of the successive generations are very different in appearance, so different in fact that they have frequently been described as distinct species and regarded as such till their identity was revealed by a study of their life histories. One very interesting case of this sort is that of the alder blight aphis which alternates between maples and alders. The forms on the two hosts were long supposed to be two species till their histories were followed by the late Mr. Pergande of the U. S. Department of Agriculture, when it was disclosed that the stem

mothers on the maples produce winged individuals which migrate to the alders and there give birth to the supposed alder species; and that the fall generations of these in turn produce winged individuals that go back to the maples and there give birth to the sexual forms of the supposed maple species. Furthermore, many of the generations on each host are quite different in structure so that altogether the species goes through a long series of changes before getting back to the original egg-producing forms from which each year's cycle takes its origin.

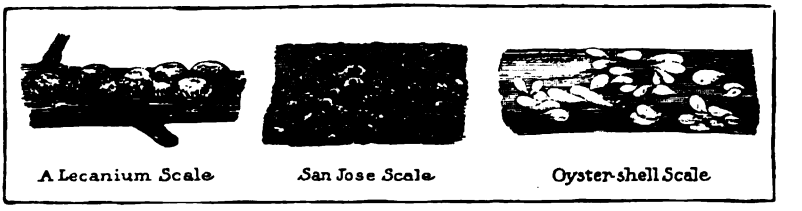


Fig. 11.—SOME COMMON SCALE INSECTS

SCALE INSECTS.

These pests are well named "scale insects" because most of them look like nothing so much as tiny flat scales attached to the bark or leaves of the plants on which they live. Scientists have named the scale family the Coccidæ (pronounced kok-si-dee), because the first species known was called *Coccus*, a word derived from a Greek one meaning a berry; so the name has little significance in most cases, though some scales are very much like berries in form.

The scale insects are probably the worst enemies with which the fruit grower has to contend. Sixty-five different kinds known in Indiana were described and figured in the last annual report from our office, and there are a great many more than this distributed all over the world. Many of the worst, which are now abundant everywhere, were imported into the United States in the days before inspection and quarantine laws were supposed to be necessary. Fortunately, however, not nearly all the species are numerous enough to be dangerous, and a great many occur only on greenhouse plants in northern latitudes. But some scales are so well known that their common names are as familiar to the farmers as the names of his fruit trees. For example (fig. 11), there is the one called the San Jose scale,

(pronounced *san-ho-zay*, like the name of the town in California where it was first discovered in this country). Then there is the oyster-shell scale which looks like a small clam shell, also the Putnam scale and the scurfy scale, and many others with less familiar names. Last June everybody noticed those white fluffy masses on the branches of the maple trees in towns and cities all over Indiana. These were the females and egg cases of the cottony maple scale (fig. 13), known to entomologists as *Pulvinaria vitis*, which for some reason was particularly abundant in 1916. It infests the various kinds of maple trees, the linden, the sycamore and also grape vines. This scale and its relations are much larger than the members of the San Jose scale tribe, and the large white egg cases make very conspicious objects on the under sides of the twigs.

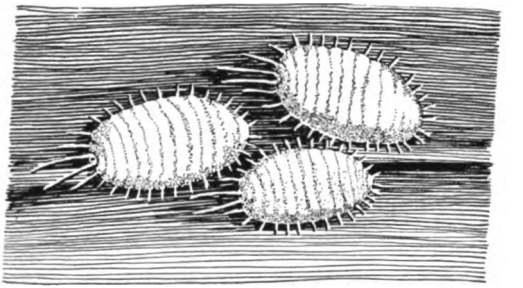


Fig. 12.—MEALY BUGS ON A PALM LEAF (Enlarged about 10 times.) A common greenhouse pest belonging to the scale family.

Another class of scale insects with which florists are acquainted in greenhouses particularly is the pest called the mealy bug (fig. 12). Mealy bugs are small soft-bodied creatures covered with white tufts of wax and having a pair of long, thread-like, waxy tails. They differ from other scale insects in not having a scale-like form at all and in retaining the power of crawling about through their entire life-time.

All scales have sucking mouth-parts similar in every way to those of the aphis, shown in figure 3, except that the labrum (*Lm*) and the labium (*Lb*) are exceedingly small; but the four bristles (*Md* and *Mx*) are well-developed and those of the second pair are united to form a sucking tube. The scales live entirely on the sap of trees and other plants and they obtain their food by thrusting the four bristles beneath the bark and sucking the liquid up through the channel between the united pair. Most

of them spend all their lives, except the first few hours or days, at rest with the mouth bristles inserted full length into the tissues of the plant, continually filling themselves with the nutritious juice, which of course takes the food away from the host plant; and if the parasites are numerous enough the unfortunate plant becomes starved and will eventually die unless the owner comes to its rescue.

The scales being pests of the piercing and sucking type must be killed either with a contact insecticide or by fumigation. It is the usual practice to treat deciduous trees during the winter with lime-sulphur or scalecide contact sprays, the fumigation method being used mostly in California and Florida on oranges and lemons which are always in full leaf. But sometimes, when winter spraying has been neglected, the pests become so numerous that they must be treated in summer, in which case one of the summer contact sprays should be used, because lime-sulphur and scalecide are both harmful to the leaves.

Many people find it difficult indeed to believe that those tiny shell-like things they see sticking so close to the twigs and the leaves of their trees are really insects, so little resemblance have they to any other living thing, and certainly least of all to the crawling, jumping and flying creatures we commonly know as insects. Seeing what damage they can do to the plants on which they live and how they impoverish them of their vital sap, we know, however, that at least they are living things, and the farmer is usually content to take the entomologist's word for it that they are insects.

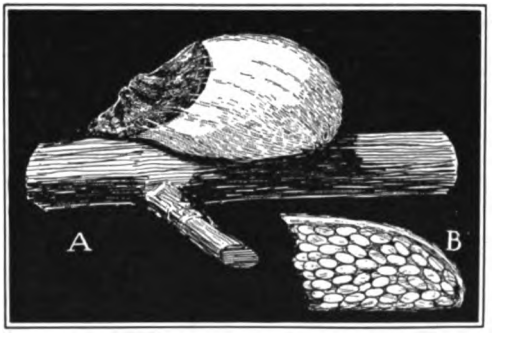


Fig. 13.—THE COTTONY MAPLE SCALE (*Pulvinaria vitis*), enlarged about 3½ times.

A, an adult female with the cottony egg sac, attached to a twig; B, part of interior of egg sac, showing the contained eggs.

But, just for the sake of those who would be shown wherefore we know them to be of the insect tribe, let us study one of the larger kinds. Take, for example, the cottony maple scale (fig. 13, A) already mentioned as forming those cottony masses on the maple trees in such abundance last summer. If you look closely at one of these you will see at one end a flattened, dark-brown, scale-like thing fitting like a cap against the oval cottony mass. This may be pulled away from the latter and by turning it over you can see that it has a soft rounded belly-like under surface with crosswise grooves marking off a number of segments (fig. 14). Then, looking closer, perhaps with a lens, there will be revealed six very minute jointed legs (*l*) and a pair of jointed feelers (*Ant*). Now, what more could you want to make a thing an insect? Anything with this combination of characters is an insect. The creature also has a mouth (*Mth*) from which four thread-like bristles (*s*) project through a tiny cone, but the bristles usually break off short and remain sticking in the bark. The mouth characters identify the creature as a scale insect.

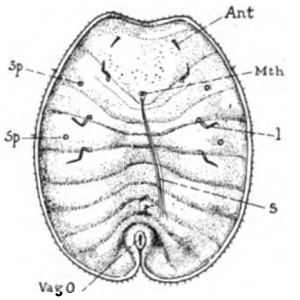


Fig. 14.—UNDER SURFACE OF FEMALE COTTONY MAPLE SCALE, (Greatly enlarged).

Ant, antenna; *l*, leg; *Mth*, mouth *s*, the mouth bristles or setæ; *Sp*, spiracles or breathing pores; *Vag O*, opening of vagina.

By examining the cottony mass you will find that it is really a little bag packed full of minute, yellowish, oval bodies, perhaps six or eight thousand of them. These are eggs laid by the scale, and the white covering is simply an egg sac formed by waxen threads excreted from the under surface of the mother. All of those individuals are females—the male scale is quite a different creature with wings and a body like a tiny fly, but I shall describe him later. The eggs in the sacs began to hatch about the middle of June around Indianapolis last season, giving birth to infinitesimal creatures with legs and antennae (fig. 15, A). They came out of the egg sacs every morning and ran actively along the twigs, eventually finding their way out to the leaves where they soon settled down along the veins, thrust their little mouth-bristles through the skin of the leaf and began to suck up the sap. These tiny crawlers in no way resemble their mothers, they look much more like young plant lice, but since they certainly hatch from the scale's eggs they give us the final ocular proof that

scales are real insects. Let us suppose now that it is summer again and that we leave the baby scales nestling in rows close to ribs of the leaves, as shown in figure 20, and come back to them later to study them more in detail and to observe the changes they go through in becoming adult scales like their parents.

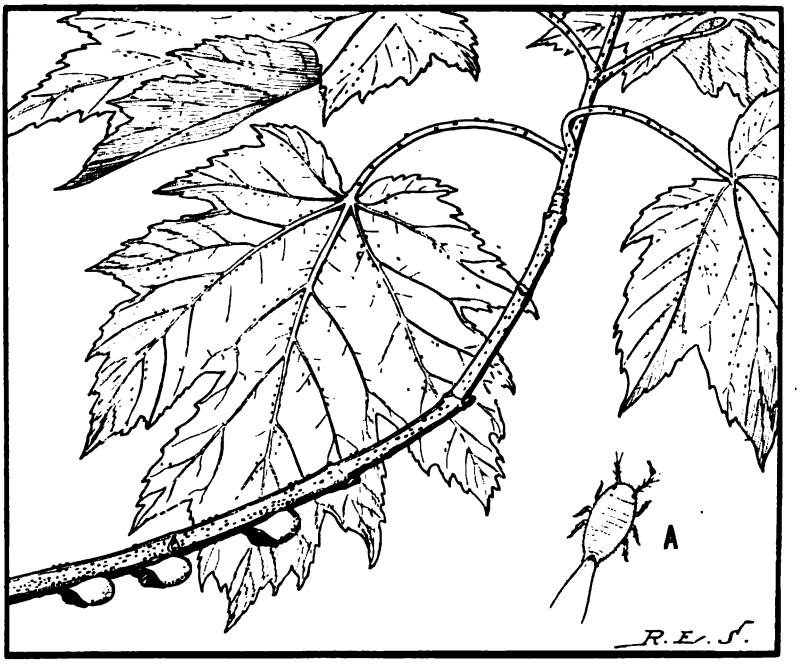


Fig. 15.—THE COTTONY MAPLE SCALE
Three adult females with their egg sacs, in natural position on under side of twigs, showing the young migrating from the egg sacs along the twigs to the leaves. A, a young "crawler" enlarged.

After seeing the great number of eggs in one of those egg sacs you will become curious to know how such a simple-looking creature as that female scale could produce them. Since she can produce eggs she must have some sort of internal organs, that seems certain; and furthermore, she must have a stomach in order to digest all that sap she takes from the tree; then she must have breathing organs because all life requires oxygen; and finally, can it be possible she has nerves and a brain. Yes, she has all of these things. Her body is packed with egg-producing organs, the ovaries, containing thousands of forming eggs (fig. 18, A). In the midst of them is a most curious alimentary canal (fig. 16). At first sight it seems to consist of a slender gullet or oesophagus

(Œ) opening into a large clear-walled intestine, from which several long coiled arms branch off. But looking closer it will be seen that the gullet really opens into a little bag (*Vent*) enclosed with the front end of the intestine, and that from it arise the tubes *a*, *b* and *c*. These tubes, therefore, are branches of the stomach. A pair of long sacculated tubes lying in the upper part of the body and which are probably glands of some sort open into the right branch (*a*) of the stomach.

The intestine is usually distended with a clear liquid. This liquid, the discarded part of the food sap, is the honey dew that the scale excretes in drops. It resembles the honey dew of the aphids, and some species of scales discharge so much of it that it forms a sticky coating over the leaves, in which a black fungus is likely to grow so thick as to give the leaves the appearance of being covered with soot.

The breathing organs of the scale consist of a great many minute tubes called tracheae that branch throughout the entire body-cavity from four small apertures, the spiracles, situated on the under surface of the body. The air enters these openings and is distributed through the tubes to all the inner tissues as if the entire body were a lung.

The nervous system of the scale is indeed a very simple one. It consists of two small masses of nerve tissue, called ganglia, from which nerves are given off to all the other organs. The first ganglion lies just in front of the mouth and is the brain. Two nerves connect it with the second ganglion, which lies close behind the mouth. From this one arise most of the nerves of the body.

But of all the organs in the body of the scale the ovaries are the largest and the most important. In fact the female scale in the spring is to be regarded as simply an egg-producing factory, working day and night pumping up sap to keep her stomach canals full of nourishment for the growing eggs that closely pack the cavity of her body. Her sole reason for being is reproduction. She impoverishes the tree to produce thousands of others like herself having no other object than to do likewise in their turn.

Each female lays several thousand eggs. By spreading all the eggs in one large sac evenly over the bottom of a small glass dish I estimated that there were eight thousand of them after counting a hundred one by one and then marking off the rest in areas corresponding in size with that occupied by the hundred. This

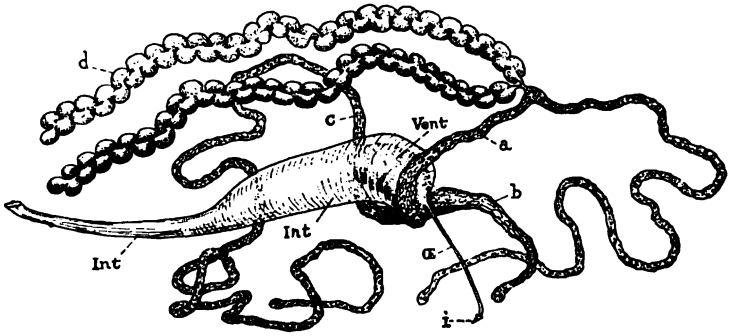


Fig. 16—ALIMENTARY CANAL OF THE COTTONY MAPLE SCALE AS SEEN FROM RIGHT SIDE

The gullet on oesophagus (*OE*) opens from the mouth on the small point (*i*) that fits between the bases of the sucking bristles, and goes upward and backward to the stomach, which is the small bag (*Vent*) within the front end of the large intestine (*Int*). It has three long, coiled, tubular arms arising from it, one (*a*) on the right and two (*b* and *c*) on the left, while two large pouched tubes (*d*) branch off from the right one (*a*) in the upper part of the body cavity.

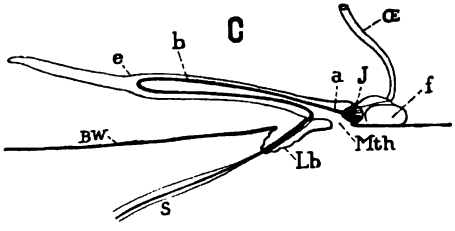


Fig. 17—DIAGRAM OF THE SUCKING APPARATUS OF THE COTTONY MAPLE SCALE IN VERTICAL SECTION

BW is the ventral body-wall. The mouth cavity (*Mth*) is on the under side of the head. A long pouch (*c*) extends backward from it within the body-cavity. The piercing and sucking bristles or setae (*s*) enter the mouth at *a* from a little cone (*i*) projecting from its front wall. They go backward first in a long loop (*b*) within the pouch and then leave it through a canal in the small conical projection (*Lb*) just behind the mouth. This cone represents the labium of the aphis (fig. 3, B, *Lb*) which holds the setae in an open groove. In the scale the groove is converted into a closed tube. The bases of the setae enter an oval muscular body on the floor of the head-cavity within which the oesophagus (*OE*) opens between the flaring bases of the setae. The liquid drawn up between the united middle setae is thus able to pass right along into the oesophagus.

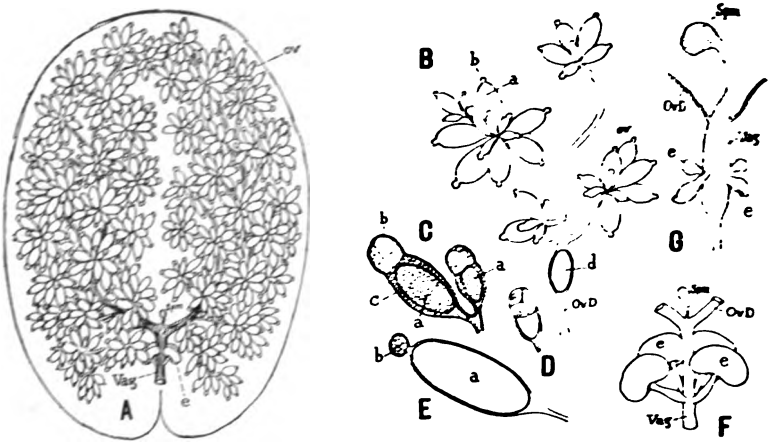


Fig. 18—THE FEMALE REPRODUCTIVE ORGANS OF THE COTTONY MAPLE SCALE.

A, Outline of body filled with ovaries, consisting of great numbers of small egg tubes (*ov*) at ends of branching oviducts. These unite in the vagina (*Vag*), at upper end of which is the sperm sac or spermatheca (*Spm*), while four mushroom-shaped glands (*e*) open into its sides.

B, Group of egg tubes at end of oviduct showing the eggs (*a*) in various stages of development, each with knob of germinative tissue (*b*) at end, (*d*) is a mature egg descending the oviduct (*Ov D*).

C, Section of young egg tubes more enlarged showing a young egg (*a*), the germ cells (*b*), and the cellular wall of young egg chamber (*c*).

D, Very young egg tube.

E, Mature egg (*a*) in egg tube, showing reduced germinative body (*b*).

F, The vagina (*Vag*), accessory glands (*e*), oviducts (*Ov D*), and the empty spermatheca (*Spm*) after the eggs are laid.

G, Same parts as in F during winter when the glands (*e*) and oviducts (*Ov D*) are small, but the spermatheca (*Spm*) distended with the male sperm threads. (See fig. 21, E.)

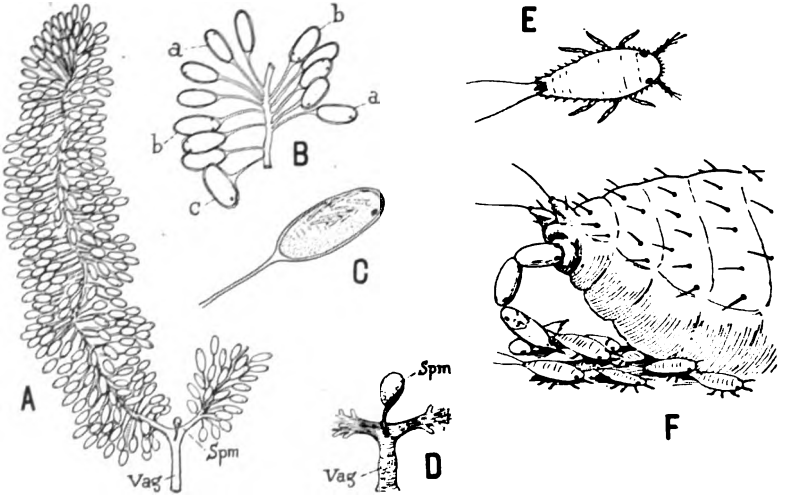


Fig. 19—THE EUROPEAN ELM SCALE (*Gossyparia spuria*)

A, The female reproductive organs, the ovaries being partly removed on right. *Spm*, spermatheca. *Vag*, vagina.

B, Group of egg tubes branching off from the oviduct. In the spring each contains an embryo (shown more enlarged at C), some with the eyes outward (*a*), others turned down the tube (*b*), others only half way round (*c*).

C, A mature embryo in an egg tube. It is unusual for eggs to develop thus in the ovaries except when they develop without being fertilized.

D, The vagina (*Vag*) formed by the uniting oviducts. *Spm*, the spermatheca.

E, A young scale shortly after hatching.

F, End of body of egg-laying female, showing the eggs emerging and the young which hatch from them within fifteen or twenty minutes.

number, which did not appear excessive, probably represents the maximum and is much larger than that recorded by others.

The San Jose scale gives birth to living young, the eggs hatching within the body of the mother before they are laid. In some other species the eggs hatch very soon after they are laid. This is true of the European elm scale which extrudes long strings of eggs that hatch within fifteen minutes (fig. 19, F). The young accumulate in a pile all wriggling and squirming in various stages of extricating themselves from their shells. Most of the scales deposit their eggs beneath their bodies and then die, but remain over them as a protecting cap till the eggs hatch.

Now let us return to the story of the young maple scales, the tiny crawlers that we left on the leaves about the middle of June. Until the first part of July others will hatch from the same sacs, for they do not all mature at once. New armies hatch out every morning and set forth on their march to the foliage.

The crawlers are always thickest on the twigs during the later part of the morning, while during the afternoon they are much less abundant and are almost all gone after three o'clock. An examination of the egg sacs showed only a few stragglers in them at this time, but next morning the twigs were again alive with them. So, one evening, I took a few twigs having twenty-four egg sacs on them home with me in a glass jar and set them out on a second story porch in order to find out at what hour the young emerged. I arose at five, the sun was just coming over the tops of the trees but not yet striking the porch—I was up before the little scales. With a lens I could see that they were not even stirring yet. At six I looked again; the sun was shinning brightly on the jars, the crawlers were out in force, while the end of each egg sac was filled with a struggling mass of them. They were emerging from thin places in the waxen bags where hundreds of the little creatures had widened small crevices to gaping exit ways. At seven and eight o'clock great hordes were swarming over the twigs and the sides of the jar.

I repeated these observations on three successive mornings, each evening brushing out all young ones that had hatched during the day, and the results were always the same—the crawlers emerged about half past five.

On the third evening I placed the jar in a closet and at half past seven in the morning there was scarcely a sign of life. Then I put the jar in the sun and at eight the crawlers covered everything. This experiment gave the same result on two successive

mornings, and on the sixth I kept the jar wrapped closely in a thick black cloth till ten o'clock, but when examined many of the little scales evidently became too impatient to wait longer and were coming out light or no light, though not in such swarms as presently appeared when the light was fully admitted. All this week, June 25 to 30, the weather was warm, the sort that insects like to hatch in, and it was probably warmer in the closet than out of doors, yet the creatures did not come out till they beheld the light of the sun, except when this was delayed too long. Evidently they are true sun-worshippers. Probably the egg-laying period extends over two weeks and those eggs that hatched each morning reached maturity during the preceding twenty-four hours. The eggs in the rear of the sac are naturally the oldest and hatch first. Three egg sacs kept under observation delivered young for sixteen mornings, though in greatly decreasing numbers after the first ten days.

The tiny specks of life no bigger than pin points that come out of the eggs have little resemblance to their mothers. Their bodies are flat, semitransparent and oval, with no separation of of the head from the rest, but the head end is marked by two prominent black eyes and has a pair of rather long, jointed antennæ sticking out from beneath (fig. 15, A). At the rear end there is a pair of delicate thread-like tails, while on the under surface are six little legs on which the creature runs actively about.

But what a forbidding world the infant encounters—nothing except the bare, smooth bark of the twig on which its delicate little mouth-bristles can make no impression. Where shall it go to find nourishment? Its first sensation must be an instinctive fear of starvation. At first most of them crawl slowly about in all directions inspecting the neighboring parts of their twig, but when the day gets warmer they become more active, and now again the tiny eyes perceive in the far distance, between patches of glowing green, the light that waked them in the morning. Light means life, their instincts tell them that, and soon they are off in the brightest direction as fast as their little legs can carry them, which is an inch a minute, but this pace they maintain with scarcely a deviation as long as the road is good. I marked two points on a twig an inch apart, and almost every traveller covered the intervening space in just sixty seconds, always toward the light.

Their road will take them to the leaves and the journey is mostly an uneventful one. Pitfalls there are and snares of web

left by the careless caterpillars of the tussock moth and possibly enemies, but generally the way is smooth and dragons scarce and death seldom comes to the little pilgrims. Occasionally one loiters by the path to rest or to explore some interesting crevice or rough place in the bark, and now and then one turns back for an inch or so, but eventually each retraces his steps with the rest. For the most part the whole army marches uniformly along at maximum speed.

But here they come to a forking in the road—what now? Nothing except those which happen to be on that side unconsciously follow the curve till it leads them out upon the branching twig, while the others continue their course along the principal stem. The next forking may be at the stalk of a leaf and in the same way the travellers in line with its base go out upon it, and the others pass on till the terminal foliage is finally reached.

I turned my attention now to those pilgrims approaching the base of a leaf. The leaf is their immediate destination, the delectable mountain tops where the mouth-bristles will be first unsheathed to draw the life-giving sap from beneath the tender epidermis. Here the little creatures will settle down in glad repose and spend a month or so gathering strength and substance to take them safely through the hardships of the winter; but before the leaves shall fall they must travel back again to safer quarters on the stems or else be lost. Now I observed that when my pilgrims had attained the end of a stem adjoining this promised land they hesitated, some ran around it and others turned back for an inch or two and then went forward again as if this didn't seem to be quite what they expected after all. However, within a few minutes they all ventured out upon the leaf, some on the upper surface and some beneath, where they wandered about in a dissatisfied manner I had not looked to see. I supposed they would be eager to tap the succulent field flowing with hidden veins of liquid food, but the perverse little creatures did not seem to be so at all. Therefore, let us leave them here again for a while—they were probably not as hungry as I imagined them to be.

In fact, I do not think now they were impelled to make their journey through the pangs of hunger. I found by experiment that they could go for two days without food and still be able to travel, and that many will remain alive for five days if kept in a moist jar, though after two days they become to weak to crawl. It was their passion for the light that led them outward and not

any instictive knowledge that their food lay in this same direction. To test this opinion I brought a populous branch indoors and placed it on a table with the leaves turned toward the window. The course of the travellers was in no wise checked or changed. But now I reversed the position of the branch and immediately each tiny marcher wheeled about and inside of a minute the whole army was traveling back to where it came from. Even those that had almost attained the bases of the leaves returned to the twig, and soon the foolish creatures has massed themselves on the stump of the branch whence there could be no possible access to a leaf. Then again I turned the foliage toward the light and within a minute all were retracing their journey in the first direction. Later I observed the same unreasoning tactics out of doors where I found the end of a broken twig covered with hundreds of deluded mites whose deity, the light, had played them false. The simple creatures, therefore, know not whence they go nor why, their ruling passion is to seek the source of light and in nature this but incidentally leads them to the leaves, the only place where they can feed and live. But the simple little scales do not know this. Nature found it easier to give them eyes and to implant in their beings a desire for light, than to tell them where their food could be obtained, and nature is prone to select the easiest way of doing things so long as the end desired shall be attained.

It is probable that the migratory stage is the principal time when the scales becomes distributed to other trees in the neighborhood, for suppose some larger insect, or a sparrow or robin alights upon a twig where hundreds of the little crawlers are in motion, it is certain that some of them must soon be upon the feet of the intruder. Presently they are transported to some other maple or linden growing near on which they disembark as pioneers to become the founders of a future colony perhaps on virgin territory.

Once more going back to the pilgrims that had reached the leaves, we see them wandering about both on the upper and the lower surface for a considerable time, as if at first they could not conceive why their journey should end here. But soon they seem to have sated their feast of light for most of them finally gather on the under surface, where, *with heads pointed toward the base*, they take up positions in rows along the veins, and on the shady side of these if the light be strong in one direction. Now at last hunger rules, mouth setæ are unsheathed, thrust into the leaf and

feeding begins—the first long repast that will probably not be broken for some till the sap begins to slaken in the fall, giving warning to the heedful that safety must be sought upon the twigs and branches. Many are doomed to meet a premature death, however, by the early dropping of the leaves; but the wiser make assurance doubly sure by returning to the twigs before a chance of danger overtakes them. However, other and important things take place in the course of the history thus briefly outlined. A sure fate that cannot be escaped will overtake great numbers of the creatures, and others will never live till winter because they are destined to be males; and this involves another story.

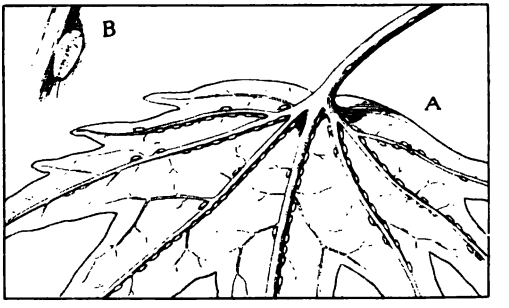


Fig. 20.—YOUNG COTTONY MAPLE SCALES ON LEAF

A, rows of young scales settle down on leaf after their journey from the egg sacs (fig. 15) mostly along the shady sides of the veins and with their heads toward the base of the leaf. B, one of the young scales more enlarged.

So familiar is everyone in any branch of agricultural work with the ordinary scale-like form of the female scale insect that few stop to wonder what the male is like, and especially since he seldom forces himself upon one's notice. Even entomologists themselves were for a long time unacquainted with the males of most of the scale species. But males there are as we shall see, for they will appear shortly in great numbers.

The following history of the cottony maple scale from the first of July to the last of November is based entirely on observations made during the summer of 1916, in Indianapolis. It differs in some ways from the published accounts but the insects may not observe the same dates everywhere nor on different seasons at the same place. That summer was unusually warm

and the trees suffered greatly from the allied attacks of scales, caterpillars, red spiders and various diseases, and at times from too long periods of drouth, so the scales may have been forced to vary their usual program.

By the end of the first week in July the crawlers had practically all left the egg sacs of their mothers, who by this time were dead, their duty being ended, and the beautiful cottony cases were shrunken, discolored by the weather, and often hanging in shreds from the limbs. Millions of the young scales were, however, established on the leaves, mostly on the under surfaces, though one lot of samples was received at the office in which both the upper and lower sides were literally covered with them. Probably in such cases the pests were present in such numbers that all could not find convenient footing on the under surfaces. The youngsters grew rapidly and within two weeks had moulted, i. e., shed their first skins. They were now pale yellowish with the green color of the leaves showing faintly through their transparent oval bodies. They were still plastered flat against the leaves in their original positions, though any of them could move if it wanted to, for when a bunch of fresh infested leaves was picked and allowed to dry for a day all the little scales drew up their sucking bristles, folded them back in a loop within the mouth sac just as when they were born, and walked nimbly away, perceiving that something had checked their food supply and that it behooved them to look for fresher fields. Yet, until the first of August, it was very seldom that a young scale could be found anywhere on the twigs, albeit I did find half a dozen after long looking, but these were mostly dead. Even in the neighborhood of dried or dead leaves on the trees I found no scales on the branches, to which they might have been expected to retreat in the emergency. On the green leaves they continued to grow.

For a week now I neglected the scales for more urgent duties and did not examine my observation trees again until the first day of August when at once I saw that things had been doing in the meantime. There were now a great many scales along the under sides of the twigs on the cut-leaf maples and a few on the lindens, a great many more than could be accounted for by assuming that they were overlooked earlier when younger and smaller. They were at places, too, where the leaves were healthy and still occupied by many other individuals, so their withdrawal from the foliage could not be explained as due to unfavorable conditions on the leaves. From this time on, morever, they

came back to the twigs in increasing numbers, especially on the maples, though according to some printed accounts they should have remained on the leaves till fall, some say October, and left then only on account of the failing sap. I cannot explain their unreasonable action—a month earlier they perished if they could not reach the leaves, now for no evident reason they were leaving them. Apparently many went back to the twigs as soon as their beaks were strong enough to penetrate the bark, and perhaps it was because the leaves were over crowded.

Of course, great numbers still were on the leaves, and after the first of August, it was to be noticed that these were not all alike. About half, instead of having the broadly oval shape (fig. 21 A, *a*) were much more slender, rounded at one end and narrowed at the other (*b*). By the middle of August many of the latter showed a pair of long delicate, white, waxy filaments projecting from beneath the narrow end (*c*) inviting one's curiosity to look beneath and see from what they came; and, doing so by lifting one edge of the scale, there was revealed a perfect little winged insect. The creature would seem somewhat dazed at first as if it had been waked from a sound sleep by the removal of its cover, then it would unfold its legs, spread out its antannæ and run off so briskly that you could hardly believe it had never been on its feet before. Some, again, would open their single pair of wings, dart into air and be seen no more. If you lightly glued one to the point of a pin and held it beneath the microscope you could see the tiny wings suddenly extend straight out sideways, almost with an audible click, and then begin to whirl with a motion so rapid that nothing but the faintest blur was visible.

But, you say, what was the creature doing under the scale? Why, it belonged there—it is the male scale himself (fig. 21, C) that sometimes before shed his old skin, secreted a thin covering of wax and remained under the latter while developing into the adult form. Lifting the wax cover a few days earlier would have revealed him in an immature stage shown at D in the figure. This stage is the pupa, and other writers say it is preceeded by another stage, the prepupa, intermediate between the larva, which is the first form, and the true pupa. Personally I did not have time to study the details of development nor the number of moults made by either sex in their growth; but authorities agree that both the males and females are indistinguishable when born and have two larval stages, in the second of which the body is larger in proportion to the legs and antennæ, but that

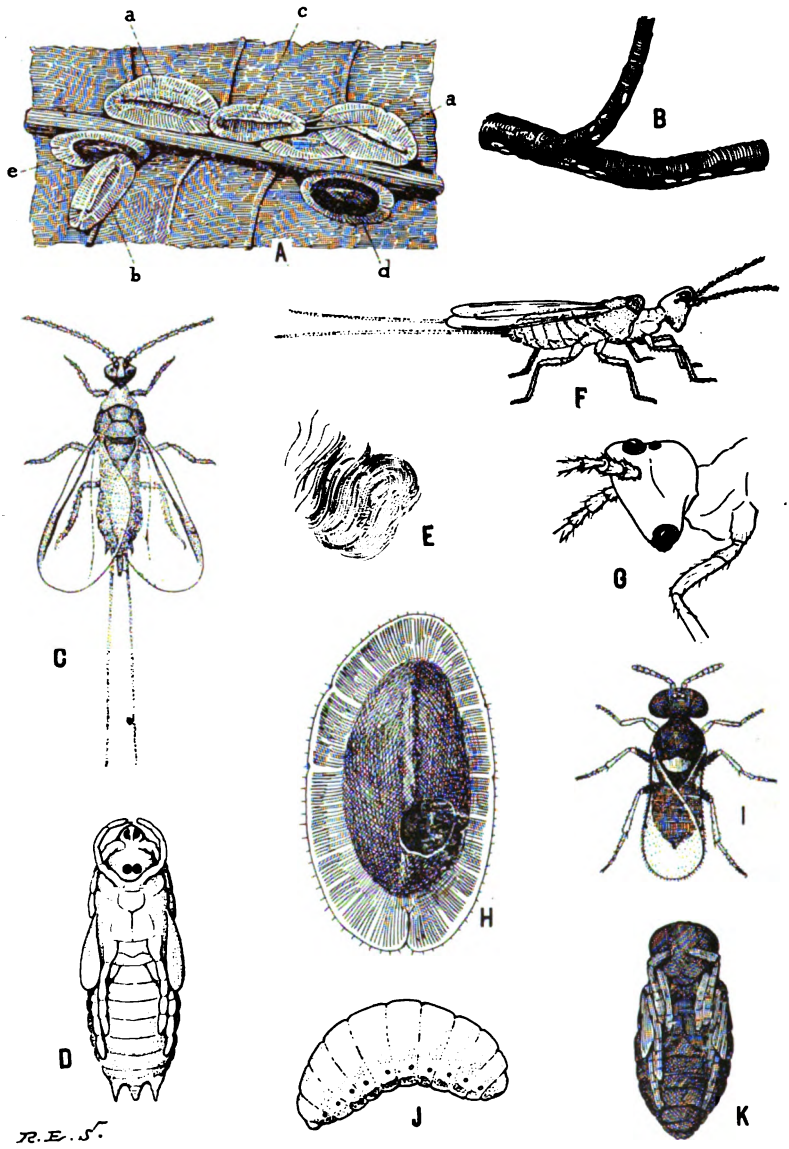


Fig. 21.—COTTONY MAPLE SCALE AND ONE OF ITS PARASITES

A, scales on leaf during the middle summer, much enlarged. *a.a*, female scales.; *b*, male scale in the second stage; *c*, male scale covering the adult, showing the two long tail filaments projecting from beneath; *d*, a parasitized scale. B, twig showing the scales migrated back to it and attached along its under surface. C, adult male, greatly enlarged. D, male pupa, the last stage before the adult. E, group of spermatozoa from the body of the male. F, side view of adult male. G, head of male showing upper and lower sets of eyes. H, a scale that has been parasitized, greatly enlarged, showing hole from which mature parasite escaped. I, adult female parasite (*Coccophagus lecani*) enlarged in proportion. J, larva of parasite which lives in the scale. K, pupa of the parasite.

otherwise there is no great change. The third stage of the female is the adult stage, the full grown female still retaining the larval form, though lacking the long tail hairs. But the male, after the second larval stage, goes through two pupal stages beneath the waxy scale covering, when it departs widely from the larval form and finally becomes a perfect winged insect. The adult stage of the male is, therefore, the fifth in his development.

Most of the individuals that had gone back to the twigs by the middle of August were females, but not all—a few males might be found amongst them, and it is probable that the first to go back of both sexes were in the second larval stage. The adult females on the twigs were of a pale reddish-brown color, giving a freckled appearance to the bark. By the middle of August they were about 3-32 of an inch long, broadly ovate, being wider at the hind end which is cleft. They were still very flat but with a prominent rounded ridge along the middle of the back. The legs and antennæ are at this stage proportionally very small and entirely concealed beneath the body.

The first adult males seen during the season emerged on August 12th. The males are very trim creatures when looked at from above (fig. 21, C). They are of a light brownish color, the two transparent wings flare out gracefully at the sides of the abdomen, the large antennæ diverge in front and the long waxy tails protrude behind; but in side view (F) there is something almost absurd about their appearance. The back is curiously humped and the head is very large with a face like a grasshopper's. Before the male emerges from beneath his shell the head is bent down and the chin is tucked against the breast, but as soon as he begins to run about he elevates his head, throws out his chin and appears to comport himself with a manner of very dainty conceit in spite of his ridiculous features. In fact he is one of the most dainty creatures alive, for he neither eats nor has either mouth or mouth-parts—these gross organs of the appetite being discarded in the larval stage. Moreover, where his mouth ought to be, he has a pair of large round eyes, notwithstanding he is provided with two other pairs on the top of his head (fig. 21, G). Think of it—eyes instead of a mouth. From our material plane we can only pity a creature doomed to see food but never to taste it, but we are only human. The consuming passion of the midget male scale is love—marriage is the end of his existence; perhaps, after the manner of scales, not one marriage but several. Truly he lives on love, though his existence is

brief at best, and surely his is a noble passion, for courtship with such plain and unattractive things as the females of his species can offer few allurements to a creature who is all eyes.

Within the body of the male are packed in special containers thousands and thousands of the most minute living threads (fig. 21, E), which are the agents that carry his share of heredity to the following generations. Each female that accepts him receives into her sperm sacs a store of these threads which are retained there to fertilize the eggs as they ripen in the spring.

Referring back now to the drawing (fig. 21, A) showing the scales on the leaves, notice that two of them (*d* and *e*) have dark, swollen centers. This marks one of the tragedies in the life of the scales, but one of the fortunate things for the life of the tree. These abnormal scales are parasitized—each one contains not the inner organs of the scale but the pupa of another insect, a minute wasp whose parent with a sword-like sting laid an egg some time previously in the body of the scale when young. This egg hatched into a legless worm that fed on the entrails of the scale and grew till it became a fat, white grub (fig. 21, J) that completely filled the emptied shell of its helpless victim. Then it shrunk somewhat and changed into the blackish-brown pupa (K), which later transforms into the winged adult (I), that finally liberates itself from its prison by cutting a large round hole through the roof near the hinder end (H). On many leaves fully 50 per cent and more of the scales were destroyed last summer by this parasite whose name is *Coccophagus lecanii*, though the creature itself is scarcely larger that the dot over one of the i's in its second name. The adults began to emerge from the scales on the leaves during the first part of August, and later those on the twigs were affected. This insect is known to attack other species of scales related to the maple scale and is a friend to the trees and all concerned in their welfare. The species pass the winter as grubs within the bodies of the overwintering scales.

Fig. 22.—FEMALE SCALES AWAITING THE RETURN OF SPRING

Now, after the male scales have all emerged, after the mating season is over and the bridegrooms are dead and blown away, after the leaves are fallen, then the story of the scales is almost ended. Nothing remains but the rows of fertile females clinging to the under surface of the twigs and branches (fig. 22) patiently enduring the winter blasts till, on the advent of spring, their ovaries mature and produce the eggs from which the next year's brood will hatch.

Now is the time to spray—give the trees a through treatment with lime-sulphur solution, soluable oil, or kerosene emulsion, either in the winter or the early spring before the leaves are out. Lime-sulphur diluted with six parts of water is probably the best general winter spray for scales, but for city purposes it has two disadvantages. Its odor is very disagreeable and it will discolor white house paint. Therefore, houses must be protected from it when spraying is done where the mist is likely to blow on them. Scalecide is one of the oil sprays commonly used for scales and is entirely effective on the cottony maple scale when diluted with fifteen to twenty parts of water. Probably the most convenient spray to use on small trees close to a house is kerosene emulsion, but unless this mixture is thoroughly emulsified it will not be effective and it is likely to injure maple trees that are not in the best of health.

While the parasites, the falling leaves and the winter's cold may have killed off 90 per cent of the summer host a sufficient number still survives to replenish all the lost if the following season prove favorable to them. A summer spray of nicotine sulphate, 1-300, with a strong soap sticker, is effective on the very young scales, but it is difficult to apply when the trees are in full leaf and far more expensive than a few gallons of lime-sulfur prevention sprayed when the leaves are gone and the pests have been reduced by nature to a minimum of numbers.

The foregoing account of the cottony maple scale will serve to give the reader a general idea of the life and structure of all the scale insects, though most of them do not form a special sac in which to lay their eggs; the general custom with them is that the female deposits her eggs beneath her body and then dies while her dead and dried body remains adhering to the bark as a protective covering over the eggs. In one large group, including the San Jose scale and its relations, the female sheds her legs with the first moult so that ever after she has no power of locomotion and must remain for the rest of her life at one spot. These scales

Fig. 23—THE CHINCH BUG

In the spring the adults (*L*) leave their winter quarters (*A*) and fly to fields of new wheat (*B*), laying their eggs (*G*) about the roots of the plants. At harvest time (*C*) they are still mostly immature when they set out on foot in great armies (*D*) for the nearest field of corn (*E*), where they do their greatest damage. In the fall the females lay their eggs on grasses in the corn field (*F*) where a second generation matures by fall that lives under rubbish and bunch grass till the spring (*A*).

In their growth from the eggs (*G*) the bugs go through five stages (*H* to *L*).

secrete a wax from their upper surface which, inclosing the cast skin, forms a separate covering over the true insect. When the infestation is bad the twig of the tree may become entirely covered by a scaly crust, the accumulation of many generations of the pests.

While the scale family as a whole is one of the most destructive groups of all the insects, several foreign members of it are of great commercial value. The dye stuff called cochineal, for example, is obtained from a scale insect called *Coccus cacti*. Shellac, the material from which varnish is largely manufactured, is a scale product, being the wax secreted in great masses by a species called *Tachardia lacca*. The beads known as "ground pearls" are the shells of a scale that lives in the earth.

THE CHINCH BUG.

The chinch bug is an enemy of corn, wheat, barley and grass but especially of corn, and when it is abundant it is the worst of all the corn pests. Like the army worm, however, it is not always present in destructive numbers. Wet seasons are not favorable to it, and after several such summers in succession its numbers are reduced to a minimum. On the other hand, two or more dry seasons in succession are likely to bring it forth in vast hords. Chinch bug injury is the same as drouth injury, each depriving the plants of their normal supply of sap, for these insects belong to the piercing and sucking order which includes the aphids and scales. So a favorable season for the chinch bug is doubly hard on the plants attacked by it. The pests feed on all kinds of grasses and cereal plants but attack few other varieties, and while they may completely destroy pasture grass they seldom injure any other kind of forage crops such as clover and cow peas.

The species passes the winter as adult insects (fig. 23, L) under any kind of shelter that will afford it sufficient protection from the cold, but is particularly partial to bunch grass. In the spring the bugs emerge from their winter quarters (A) and seek out fields of new wheat (B). Here they lay their eggs about the bases of the plants from the last of April through the month of May, and then this winter generation dies. The eggs soon hatch and the young bugs live in the wheat fields till harvest time (C) when the drying of the stalks impels them to migrate to some later crop. At this time they are in all stages of development (H-L), though there are not many of the fully developed winged

adults (L); but all of them, winged as well as wingless, start out *on foot* (D) for the most accessible green crop in the neighborhood on which they can subsist. This will probably be either corn, oats or barley, but since the pest is generally most abundant in corn growing sections, corn is usually the crop that suffers now. If they are allowed to reach a corn field they swarm up on the nearest stalks in countless multitudes (E) killing all as they go, sucking the plants as dry as if they had been cut off at the roots. This is when the chinch bugs do their greatest damage because they now attack in mass. The concentration of their numbers on a comparatively few plants at a time is more than the latter can withstand. Before and after this they are scattered over a much larger area and the effect being distributed is less destructive.

When this generation reaches maturity the insects fly about the field and the females deposit their eggs mostly on grasses growing amongst the corn. These eggs produce a second generation which matures from August to the middle of October, but usually does much less damage than the first generation, because the individuals are now more widely dispersed and the corn, being older, is better able to endure their attack.

In controlling the chinch bug clean farming is a very great asset because the destruction of all rubbish, waste and weeds on and about the fields breaks up the winter quarters of the bugs and exposes them to freezing. Especially should bunch grass be obliterated.

During a favorable chinch bug season, however, the farmer must be very watchful to prevent an army of the pests from gaining access to his corn after any neighboring wheat is harvested. The habit which the bugs possess at this season of travelling overland in great hords (D) is the vulnerable point in their life history, for it is then only necessary to place some impediment across their line of march. In very dry seasons a dust furrow, made by dragging lengthwise a triangular trough over a strip of well harrowed earth, forms an effective barrier against them if carefully watched. They may be trapped by digging post holes at intervals along the bottom of the furrow or killed with kerosene. But the slightest shower will put a surface on the dust that will allow the bugs to crawl up the sides of the furrow and proceed upon their way, so, therefore, it is much safer to pour a line of No. 7 road oil, crude creosote, or liquid tar along the bottom of the trench, replenishing as often as is necessary and keeping constant

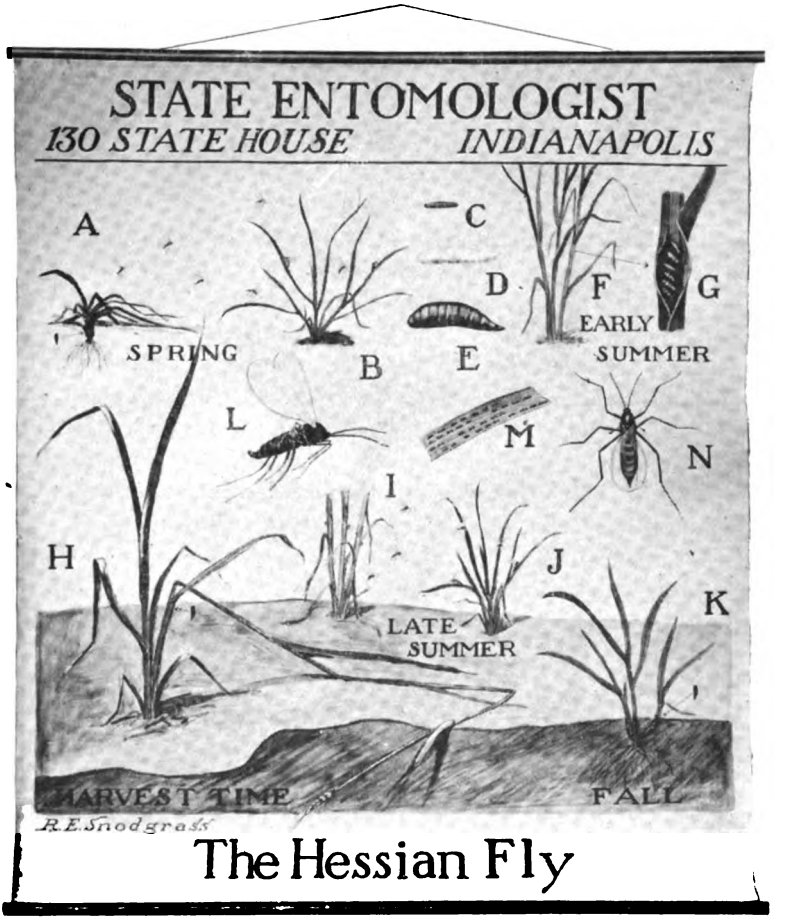
watch by day and night to see that the surface does not dry, for just so soon as this occurs the multitudes will swarm across and the results of all your efforts will be lost.

The cost of this procedure is not great and in any case must certainly be less than the loss resulting from a ravished crop. If the pests, however, do gain access to a corn field they may be checked by spraying with kerosene emulsion when this is practicable.

THE HESSIAN FLY.

These pests (fig. 24) spend the winter as pupæ in the bases of the wheat stalks, producing a sickly condition of the wheat which causes the leaves to lie prone upon the ground. In the spring (A) the adults emerge and fly off to uninfested wheat (B) where each female deposits from 100 to 150 eggs (C) in rows on the leaves (M). The eggs hatch in a few days and the young legless maggots (D) wriggle down the leaf to its base where they conceal themselves between the leaf base and the stalk. Here they feed on the juice which they extract from the plant, causing the latter to swell slightly at the points where they are located. After about four weeks the larvæ reach maturity and transform into pupæ within their skins, which latter harden into cases resembling a flax seed (E) and take on a dark reddish-brown color. The base of each leaf may harbor a number of these flax seed pupal cases which are arranged side by side in the swellings of the stalk (F and G).

The effect of the maggots on the wheat is to weaken it by the extraction of sap, so that at harvest time (H) the whole plant has a sickly, prematurely ripe appearance, the head is small and probably worthless and the entire stalk is likely to fall over and lie on the ground. The larvæ change to pupæ about the time the wheat is ripe and the adult flies later emerges from the stubble (I) to seek fields of new fall wheat (J). At this time badly infested fields are swarming with the insects which are tiny, blackish flies (L, female, and N, male) with two smoky transparent wings showing pinkish and blue reflections. The eggs at this season are laid on the fall wheat but the larvæ now, in anticipation of cold weather, make their way down to the base of the plants and even below the surface of the ground, and the pupæ of this brood are to be found in this location during the fall and winter (K and A). In the spring the adults emerge again and start the cycle of the second year's broods.



The Hessian fly is the great enemy of wheat, but will attack rye and barley also. Ten per cent of the entire wheat crop in the United States is destroyed by it every year and in some parts it is said that twenty-five to fifty per cent of it is ruined. The pest is our heritage from the Hessians who are said to have brought it with them to this country during the Revolution in 1779, and it so gets its name. The weakest point in its life history is the time in the fall when the second brood of adults emerges from the stubble (I). The females will lay their eggs only on wheat, rye or barley and will disappear within a week or ten days if they can find none. Therefore, the farmer who knows there are Hessian flies in his field should postpone the planting of his fall wheat (J) until he is sure that the wheat will not be up until the flies are gone. This is where careful calculation is necessary, for it is always desirable that the fall wheat should be in as early as possible in order that it may make sufficient growth to protect its roots from the effects of frost. So, escaping the Hessian fly sometimes means getting caught by an early winter. It is the old problem of how to avoid Scylla without falling prey to Charybdis. Here the county agents can render excellent service in their respective districts by keeping watch on the flies and advising the farmers as to the right time to plant in each season, for naturally no precise calendar date can be assigned, the exact time will vary in different parts of the state and on different seasons, though it will usually be somewhere in or near the first week in October.

The rotation of crops on infested land also helps because the spring brood will be forced to seek other fields or die if it finds no wheat awaiting it in the vicinity. Where Hessian fly is known to be in the stubble the stubble should be burnt or thoroughly plowed under after harvest in order to destroy the pupæ, and all volunteer wheat crops should be plowed under before the maggots are mature. Sometimes it is recommeded to make an early planting as a trap crop to which the flies will be attracted and then, after the eggs have been deposited, plowing it under to bury the latter before they have a chance to hatch. After this plant the regular fall crop.

Varieties of wheat with large, strong, coarse straw are more resistant to the pest than others; but any variety well tilled and fertilized so as to produce healthy plants will be much better able to withstand the effects of the parasites than otherwise.

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THE ROSE MIDGE.

The rose midge is the greenhouse pest of roses called the Reinberg fly by Indiana florists. The adult insect is a minute two-winged fly, shown greatly magnified at F and G of figure 27; but it is the larvæ or maggots that do the damage by feeding inside of the flower and leaf buds, preventing and distorting their growth and soon causing them to turn brown and then to blacken and die (fig. 25).

The pest does not live out-of-doors in the United States and is probably a tropical species that has been brought into this country and which can survive the winter of northern latitudes only in greenhouses.

Fig. 25.—EFFECTS OF THE ROSE MIDGE ON ROSE BUDS (From photograph, Davis, 27th Rep. of State Entomologist of Illinois, 1912)

The insects cease from their ravages during the winter months even in greenhouses, passing this period as a hibernating pupa in the soil. Early in the spring, however, or in the late part winter, the adult flies appear and the females lay their eggs in the bases of the flower and leaf buds. The eggs, shown at A of figure 26, hatch in two days and the young maggots (*B*), which are scarcely to be seen with the naked eye, begin feeding within the buds. They do not actually eat the plant tissue, but they extract the sap to such an extent that the young petals or leaves soon begin to dry up and eventually die.

The insect is related to the Hessian fly, which causes such destruction to wheat, and to several midges that form galls on

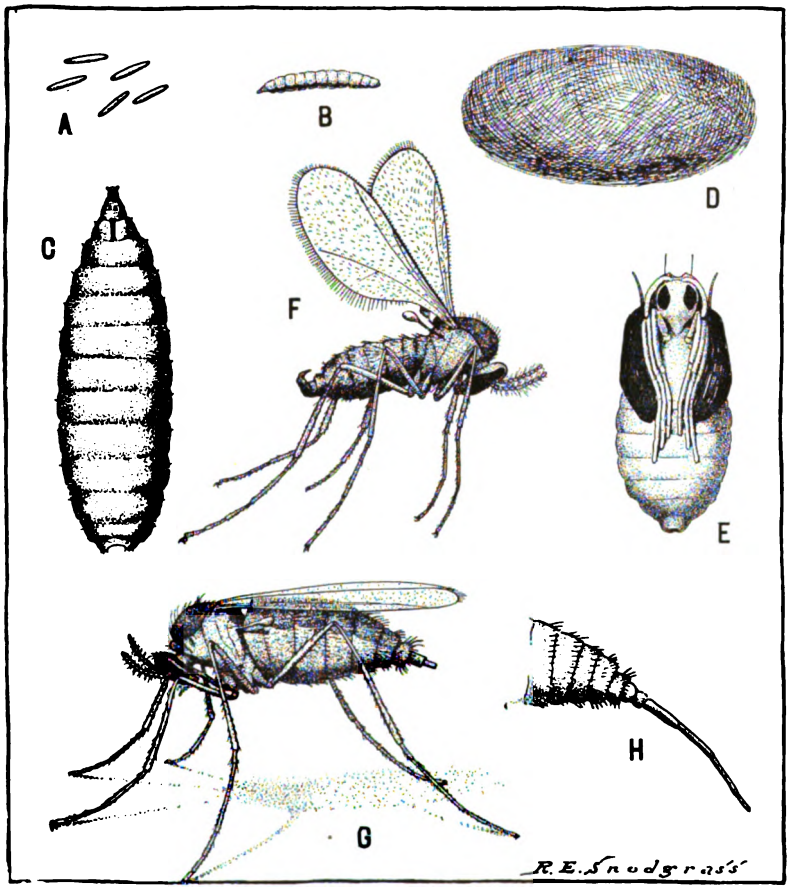

Fig. 26.—THE ROSE MIDGE, ENLARGED ABOUT 27 TIMES.

A, Eggs laid in the flower or leaf buds.

B, Young larva which feeds and grows in the bud.

C, Full grown larva which crawls out of the bud, falls to the ground and burrows beneath the surface.

D, Cocoon spun by the larva about itself in the ground.

E, Pupa, into which the larva transforms within its cocoon.

F, Adult male which hatches from a male pupa.

G, Adult female which hatches from a female pupa.

H, Egg-laying tube which the female can protrude from her body to insert the eggs between the leaves of the buds.

leaves. It is not exactly known how any of these pests obtain their food, for they have neither jaws nor piercing organs connected with the mouth, but there is a hard rod on the underside of the first segment back of the head, with two rounded points projecting in front beneath the head. These points are supposed to be used for scraping the plant tissues till the sap flows out where it can be taken up by the small mouth at the tip of the tapering head.

The full-grown larva of the rose midge (fig. 26, C) is a simple, legless maggot about one twelfth of an inch long. It matures in a week's time and then works its way out of the bud, falls to the ground and burrows beneath the surface. Here it spins a silken cocoon (D) about itself and transforms to a pupa (E) inside of it. The adult fly (F and G) emerges within a week and the females (G) lay the eggs for the next generation of maggots. They are enabled to insert the eggs into the bases of the buds by means of the telescopic end segments of the adomen (H) which can be protruded as a long tapering tube, the eggs emerging from near the tip of it.

During the warmest parts of the summer, generations may mature every two weeks, but earlier and later the stages are more prolonged and in winter the pupa remains dormant from fall till early spring, though some have been recorded as emerging as early as February.

An infestation of the rose midge is a serious thing for the florists. The hibernating winter habit of the pupa, when all the individuals will be somewhere in the soil within the houses, may be taken advantage of wherever practicable, by making a thorough clean-out of the houses where the flies have been during the season. But such a course would generally be impracticable though it might be followed if the infestation is local and confined to one house.

The only other thing that can be recommended at present is to kill the adult flies during the season when they are emerging and flying. This may be done by fumigation with tobacco fumes, which has been found to be effective if repeated every night till the flies disappear. This treatment will do no harm to the roses. Some growers prefer to burn tobacco stems in the houses at night, while others depend on the use of volatile nicotine preparations, such as "nico-fume", sold especially for greenhouses fumigation, and which are volatilized by heating or burning. A thorough treatment of this sort during one season should at least greatly reduce the numbers of the pests, and a repetition of it the following spring should exterminate them.

THE CHRYSANTHEMUM GALL FLY.

Diarthronomyia hypogœa.

This is the greenhouse pest that causes small cone-like swellings or galls to appear on the chrysanthemum leaves and stems (fig. 27, A). It multiplies so rapidly that the plants, especially young plants or cuttings, soon become so covered with the galls that their growth is checked and they take on a sickly pale color. The insect is a tiny delicate two-winged fly with a soft, reddish body and dark legs (H). It is a close cousin to the rose midge.

The females lay their eggs (I) on the chrysanthemum leaves. The young larvæ on hatching must bore into the tissues of the plant where their presence stimulates the growth of the gall, but their hatching and the manner of their entrance into the leaf has not been observed.

Each gall contains a spacious chamber that extends downward into the structure of the leaf and produces a swelling on the opposite side. Figure 27, C shows a gall with the top removed exposing the young larva within. The latter feeds apparently on the sap that exudes through the lining tissue of its cell. Some of the galls contain two or more larvæ as shown in one of those cut in a vertical plane at D. When the larva is full grown (E) it completely fills its cell and here it changes to a pupa (F) with its head end in the apex of the gall. During the feeding stage the larva turns about in any direction. The pupa has two pairs of spines upon its head which presumably it uses for cutting the exit hole in or near the apex of the gall when it is ready to transform into the fly. After the hole is formed the pupa wriggles itself part way out of the aperture and remains there. Then the skin splits over its head and down the back and the adult fly emerges (G) leaving the empty pupal skin projecting from the summit of the gall. Some of the pupæ fall out of the gall before transforming, but the fly emerges wherever they drop.

The life history of this insect has not been carefully followed, but it is certain that it completes its growth from egg to adult in a very few weeks. The flies emerge principally at night or in the early morning and even during the winter months great numbers of them come out every twenty-four hours. In cases of bad infestation small cuttings may each contain a score or more of larvæ at one time. A dozen or fifteen galls are often found on a single leaf.

The only treatment that has been used against this pest in Indiana is persistent smoking of the house with tobacco stems, combined with hand picking of the worst infested leaves. One large grower of chrysanthemum cuttings completely rid his houses inside of two months of what at first seemed a hopeless case of almost total infestation by these methods. In one month he used twelve bales of tobacco stems, each bale containing from forty to eighty pounds. During most of the time the smoking was done nightly or every other night in order to catch the flies as they emerged from the galls and to prevent them from depositing their eggs. Few of the chrysanthemums were injured by the tobacco fumes, but many other plants were seriously damaged. The hand picking of the leaves, however, is a very valuable adjunct to the fumigation, but the picked leaves should be burned at once because many flies will emerge from them even after they are a week old and completely dry.

Where the chrysanthemums occupy only a small section of a house nightly fumigation could not well be practiced. Since the flies appear to remain on the plants during the day, however, and probably do not spread much to other parts of the house it is suggested that the chrysanthemums could be covered with some sort of tent beneath which nicotine papers could be used. Hand picking may suffice in minor cases but in any case the treatment must be persistent until the pest is eradicated.

The chrysanthemum gall fly has been known in California for fifteen years, but it is only within very recent years that it has become established in the central states. It has now been reported from California, Oregon, Michigan, Indiana and Canada. We have found it in several greenhouses in different part of Indiana, and it is probably already more widely distributed in the country than we suspect. It is a native of Europe and there lives on the ox-eye daisy (*Chrysanthemum leucanthemum*) which is cultivated here, so there is danger of the pests becoming established as a permanent resident in this country.

Some species of chrysanthemums are more resistant to attack than others and the galls differ somewhat on different varieties, the color varying between green and dark red. It has been claimed that plants growing out of doors during the summer are more resistant than those grown inside, but this is not born out by the experience of greenhouse men in Indiana.

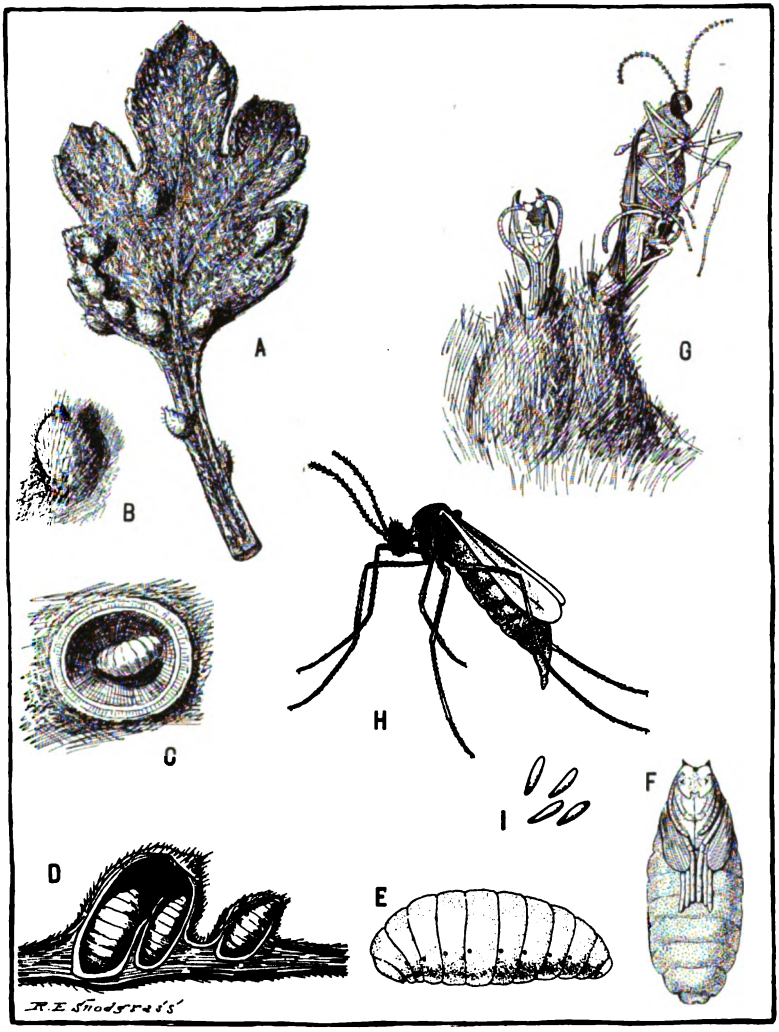

Fig. 27.—THE CHRYSANTHEMUM GALL FLY

A, Leaf covered with galls.
B, A single gall, more enlarged.
C, Gall cut open from above showing young larva within.
D, Two galls cut in vertical section.
E, Larva, enlarged about 13 times.
F, Pupa.
G, Fly emerging from a gall on right; discarded pupal skin remaining in opening of gall on left.
H, Adult female fly, enlarged about 13 times.
I, Eggs.

THE ARMY WORM.

The army worm inhabits all of the United States east of the Rocky Mountains. While the species is, of course, present every summer it is not always noticed because it is only during very favorable seasons or when its natural checks and enemies are for some reason suppressed that it occurs in those vast numbers which have given it the name of "army worm".

The worms (fig. 28, E) are the caterpillars or larvæ of a moth (A). When full grown they are from an inch to an inch and a half in length. The upper surface is brown and the lower greenish, while along each side is a reddish stripe inclosed between two black ones. The moth (A) is of a yellowish-brown color having greenish-blue reflections on the hind wings and a white spot near the centre of each fore wing. Its body is about three quarters of an inch long and across the expanded wings it measures about an inch and three quarters.

The female moth lays her eggs in the spring principally in the unfolded bases of grass leaves (B) but also on young wheat and cut straw. A hundred or more eggs may be deposited by each moth and they hatch in eight or ten days. The young worms, which are pale in color and without stripes, spread to all of the vegetation in the neighborhood, feeding mostly at night and hiding during the day about the bases of the plants or under any kind of rubbish lying on the ground, but in dull weather feeding openly in the daytime also. Growing grain and corn is the favorite food of the full grown worms, though they may be very destructive to all kinds of garden crops as well, but clover is usually exempt from their attack. In three or four weeks the caterpillars become mature (E) and then they burrow into the earth (G) where they transform into reddish-brown pupæ (H).

The moths hatch from the pupæ after about two weeks, and push their way to the surface through the soil, emerging during the latter part of summer. This generation of adults, when about a week old, lays the eggs for the fall brood of worms. The latter, however, are usually much less abundant than the spring brood and do comparatively little damage. They go through their transformations as did the others and produce a fall generation of moths of which many live over the winter in protected places, especially in more southern latitudes, and those that survive are the ones which lay the first eggs in the spring. But the first moths to emerge of the fall brood, how-

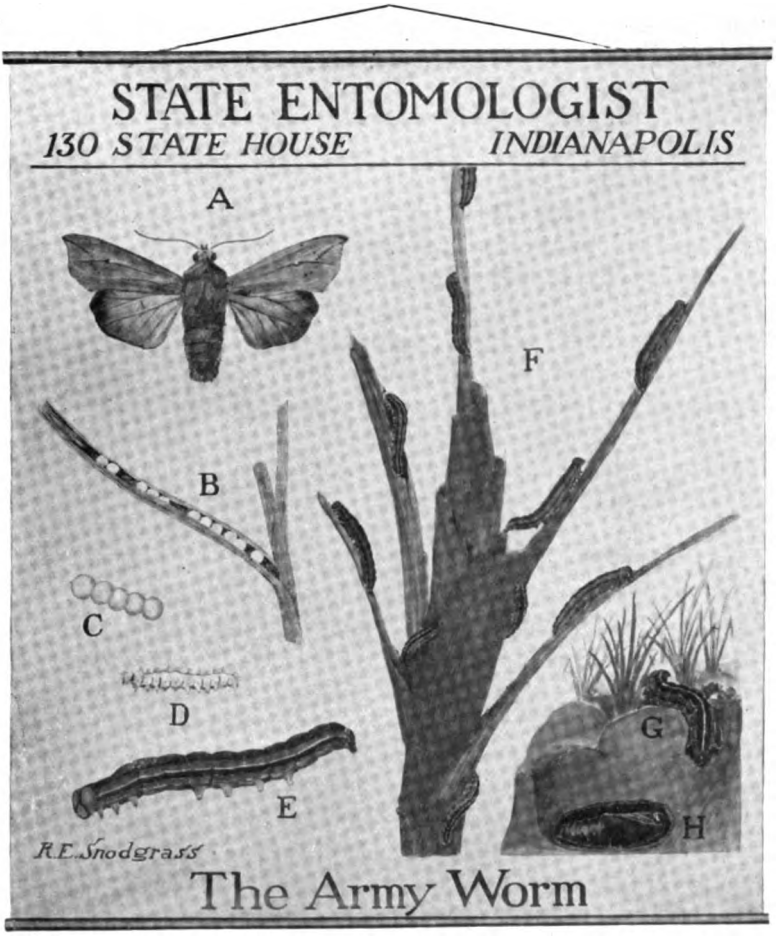

Fig. 28—THE ARMY WORM

In the spring the adult female moth (*a*) lays her eggs (*c*) in rows in the half-opened bases of grass leaves (*b*), in young grain, or in cut straw. The young worms (*d*) hatch from the eggs and spread to all surrounding vegetation, but the full grown caterpillars (*e*) prefer growing grain and armies of them often completely devastate field crops (*f*). The full grown larva burrows into the ground (*g*) a few inches and transforms to a pupa (*h*) during summer. The second or fall brood goes through the same transformation as the first, the resulting moths either hibernating over winter or laying eggs which produce larvae that hibernate. The spring moths are both those that have lived through the winter and those produced in the spring by the hibernating larvae. (Figure F adapted from Slingerland.)

ever, generally lay their eggs at once and produce a late fall crop of young worms which pass the winter in the ground or under rubbish and then complete their growth and transformations in the spring, producing another lot of moths which lay their eggs now along with those that came through the winter as adults. Hence there are two and three broods of the army worm in the northern states, but it is said they go through as many as six generations during the year in the South.

As a control measure deep fall plowing and harrowing are recommended in order to bury the larvæ and pupæ far enough within the soil to prevent the moths from emerging. Burning grass and weeds along fences and ditches during the fall and winter is good practice also because in this way many of the hibernating adults will be destroyed. During seasons when the pest is present in army numbers much watchfulness is necessary in order to discover them as they advance from one devastated field to attack an adjoining one, especially since they feed largely at night though they travel by day. When the army is discovered on the march the best thing to do is to plow a furrow across the line of advance with the straight edge away from the worms. Then dig posts holes at intervals in the bottom of the furrow and when the worms are trapped drench them with kerosene or crude petroleum. They may also be checked by laying a strip of crude petroleum, such as No. 7 or No. 8 road oil, across their path. The pests may be controlled in gardens by arsenate of lead or with bran mash (see cutworms).

Of the natural enemies of the army worm the most effective is a parasitic fly which is said often to follow the armies in swarms. The females lay their eggs on the backs of the caterpillars, from one to a dozen on each. The young maggots on hatching burrow into the body of the worm and there feed on its living tissues and juices. The victim dies about the time the maggots are full grown, whereupon the latter emerge, transform into puparia and later into another generation of flies. This fly probably plays the most important role in the reduction of the number of the worms, for the latter seldom occur in armies on two successive seasons.

Fig. 29—THE CODLING MOTH

This insect passes the winter in the worm stage. In the spring the larva changes to a pupa within its cocoon and the mature pupa pushes itself partly out of the coccoon (*a*) before the moth (*b*) emerges. The females lay their eggs on the leaves (*d*) and a large per cent of the young worms enter the calyx end of the apples. They should therefore be sprayed while the calyx is yet open (*c*). The worms bore into the young apples (*e*), excavate the core (*f*) and when full grown crawl out at the side. If the apple is still on the tree they go down the branches and if it has fallen they crawl up the trunk (*g*) to find a place to spin their coccoons (*h*) under the bark. The last worms in the fall hibernate over winter.

THE CODLING MOTH.

The codling moth (fig. 29) is the most destructive insect enemy of the apple. It passes the winter in the worm stage inside of a tough coccoon (H) spun under loose bark on the tree, in crevices about fences, under leaves or boards or any other rubbish lying on the ground, sometimes even in the cracks of the ground itself, and in packing houses where wormy apples have been stored during the fall. The coccoons are made of silk but are usually covered over on the outside with bits of leaves or bark that give them a rough appearance. Inside they are lined with smooth white silk.

In the spring the worms or larvæ transform to pupæ either inside of their winter cocoons or in new ones, but first the occupant makes a hole at one end of the cocoon, covering it again with a thin web of silk, to provide an exit against the time for emergence. The pupa is a reddish-brown chrysalis with rows of strong spines across its back. In about four weeks the moth is ready to emerge when the pupa pushes through the delicate covering over the door in its cocoon and wriggles its way out by means of its spines till it projects in mid air like a gargoyle with only its tail end remaining in the coccoon (A). Then the front end splits and the moth that has formed within pushes off a cap of the dry chrysalis skin and emerges (B). All individuals, however, do not mature at the same time—the moths keep on hatching out over a period of several weeks, but most of them have emerged about the time the petals fall from the apple blossoms. If the weather should happen to turn cold the moths may remain inactive for a long time or until it becomes warmer, but ordinarily after three to five days the females begin laying their eggs, from 30 to 100 each, which they deposit mostly on the apple leaves, and then they die after a life of perhaps ten days under favorable circumstances.

The eggs of the spring generation are laid on both the upper and under surfaces of the leaves, and the egg laying season extends over several weeks corresponding with the irregular emergence of the moths themselves. The eggs hatch in from six to ten days so the young worms should be looked for about three weeks after the petals are gone when the young apples are formed.

The young larvæ of the spring generation enter the apples mostly at the calyx end (D), though some of them bore through the skin on the side, especially where a leaf happens to lie in con-

tact with the fruit. The worm first feeds a little where it enters the apple and then tunnels to the core (E) where it eats the seeds and eventually makes the large familiar cavity filled with blackish frass and web. In about a month the worms mature, burrow to the surface of the fruit again and come out to seek a suitable place to pupate, which they generally find beneath some piece of loose bark. If the infested apple has not fallen the emerging worm has simply to follow down the twigs and branches, but if on coming out it finds itself upon the ground then it must either crawl back to the tree or find some other suitable location. This brood of larvæ transforms to pupæ about the first of August.

The summer pupal stage lasts about ten days and then the moths of the second generation begin to appear and lay their eggs. These produce the summer brood of worms which live about three weeks before pupating. All of the summer stages are shorter than the corresponding stages in the spring on account of the higher temperature, but there is always a great deal of individual variation so that the two broods overlap and late moths of the first generation may still be flying when those of the second begin to emerge, while worms of all ages are present throughout the summer. The summer larvæ usually enter the sides of the fruit and since most of the wormy apples at this season drop from the trees the majority of the worms on coming out in the fall must seek their winter quarters from the ground (F and G). In more northern latitudes there is only one generation of this pest during the season while farther south there may be three or four.

The standard remedy for the codling moth, now universally recommended, is spraying for the young worms with arsenate of lead (see page 57 of this report and the spray program in the Eighth Annual Report 1914-1915). The first spray is the important one and should be applied after the petals have fallen but before the calyx closes on the very young apples (fig. 29, C), and special care should be taken to get the spray into the open calyx cups, remembering that it is here that the majority of the worms first enter the fruit. But the other parts should not be neglected, for a considerable number of the worms enter the side of the fruit and many may be destroyed where they hatch on the leaves. The apple grower will be making his second summer spray with lime-sulphur at this time for various other apple pests and diseases, and the arsenate of lead should be added to this solution (1¼ pounds to 50 gallons of lime-sulphur).

THE CORN-EAR WORM.

This is the worm that eats the green corn on the ear (fig. 30). It is a familiar pest to housekeepers who, when preparing sugar corn for the table, are dismayed on removing the husks from a

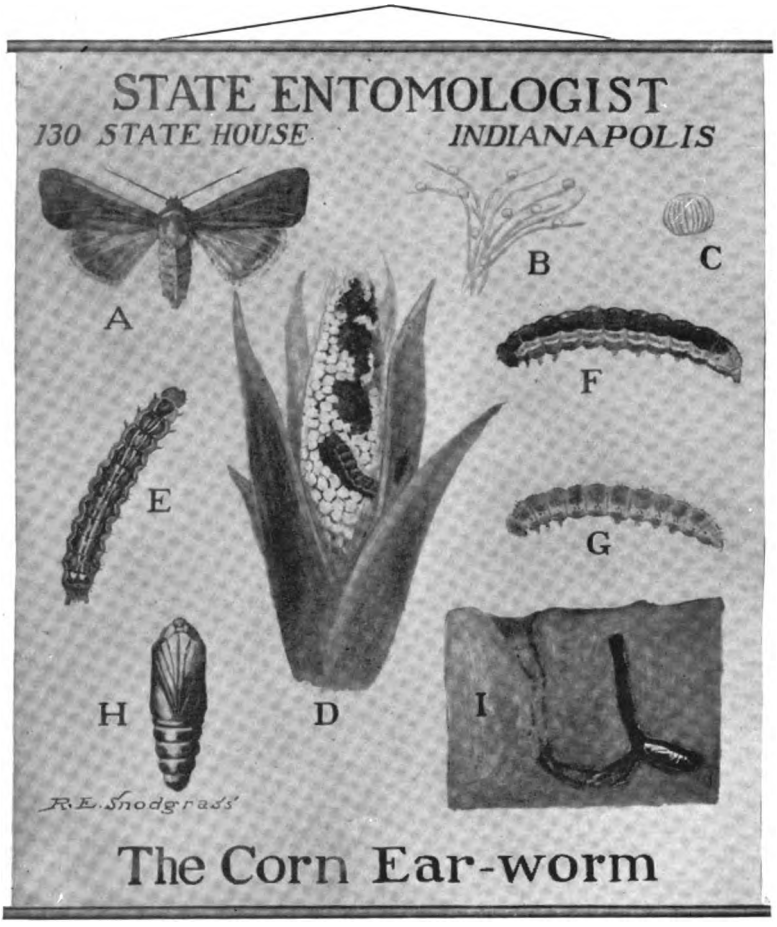

Fig. 30.—The Corn-ear Worm.

good-looking ear to find it ruined by a greenish or brownish worm with yellow and white stripes along the sides, which has eaten away irregular patches of the grains and left a black disgusting mass of excrement. Often the thief has fled, when a round hole though the husk generally tells the method of his escape. But the pest is destructive as well to field corn, only, by the time

the ripe corn is husked, the destroyer has long since departed and is now safely tucked away in a cell beneath the ground in the corn field, already transformed to a pupa, awaiting the warmth of spring to become a moth that will produce more worms on the following season. Hence it is that the farmer, knowing the damage that his corn sustains, does not always know where to fix the blame and often does not reckon the corn-ear worm as one of his enemies.

The moths (fig. 30, A) which emerge in the spring measure a little less than an inch and three quarters across the expanded wings. They are of a yellowish-brown color with darker bands and mottlings on the wings and a dark border on the front ones. They lay their eggs on young corn, beans, peas, or most any garden plants available, and the young worms hatch in five days and commence feeding on the host. Those on the corn eat a series of round holes in the still furled leaves, so that when the latter open they often exhibit a punctured design in the form of several parallel rows of perforations.

The corn-ear-worms have several aliases. In some parts they are very destructive to tomatoes and for this reason are known as the tomato fruitworm, while in the south they destroy tobacco and cotton and here go by the name of tobacco budworm and cotton bollworm.

In the central states the caterpillars of the first brood become full-grown and ready to pupate in about two and a half weeks, when they are about an inch and a half long. Some are blackish or brownish above and pale below with yellow and white stripes on the sides (fig. 30, E. F) while others are greenish with pale side stripes (G). Before pupating they burrow into the ground from two to six inches when, it is said, they construct an exit gallery almost up to the surface again, after which they descend to the bottom and excavate a chamber lined with loose silk in which the transformation to the pupa takes place (I). The pupa is a reddish-brown chrysalis (H) from which, after two weeks or longer, the adult moth emerges, ascends the exit way and pushes through the thin layer of earth on top. Probably the entire life of this generation, since the laying of the eggs has consumed about six weeks, but the next or summer generation will be shorter, perhaps about a month in length. But, like all the moths, different individuals, regardless of the season, take a varying length of time to undergo their transformations, so the second genera-

tion of adults appears over a considerable length of time, but most of them are flying by the time the corn is coming into silk, which is about the middle of July in Indiana.

Now, corn seems to be the favorite food of this insect in the north and the moths of the second brood show a great preference for the silk as a receptacle for their eggs (fig. 30, B); and thus it comes that the second brood of worms work such havoc in the green corn-ears, for all the hatching larvæ have to do is to crawl down from the silk to find a luscious dinner waiting them. It would seem that creatures with such an easy living provided should be contended, but it appears that they are not, for after eating enough of one ear to check its appetite for a while the restless worm must travel off to sample another and then another, till in this way it ruins many ears when any one would have been sufficient for its needs. Thus several worms of different ages are often found in the same ear.

When full grown the worms in the corn cut an exit hole through the husk and drop to the ground where they burrow in to pupate as did those of the first generation; but in this case, in northern latitudes, the pupæ remain in the soil all winter, the moths emerging on the following spring. In the south there are said to be as many as five or six generations during the year.

The most practicable remedy for the corn-ear worm is to break up the exit tubes from the pupal cells (fig. 30, I) by harrowing the surface so as to prevent the emergence of the moths. This should be done particularly in the fall or winter. Spraying the silk with arsenate of lead has given good results where tried, but it is generally regarded as too unpracticable to be applied on a large scale, but it can be done to protect sugar corn grown in the garden. It must be remembered that the spring brood of worms attacks almost all garden vegetables, on which they may be killed with arsenate of lead, and the more destroyed in the spring the fewer will there be to infest the summer corn. So great is their preference for corn at all seasons that it is often recommended to plant a few rows of corn in the neighborhood of other vegetables to draw the pests away from the latter. There is evidence that the corn-ear worm has been increasing in Indiana and unless some way of treating corn in the field can be devised the pest is likely to continue.

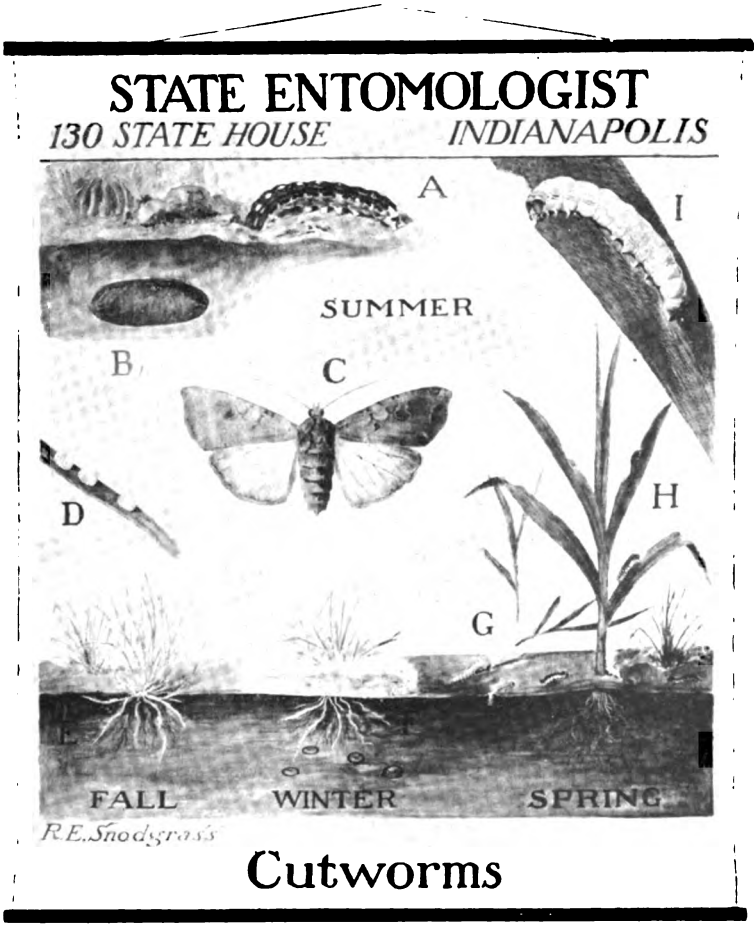

Fig. 31.—Cutworms.

In the spring the partly grown worms emerge from the soil and attack the young plants (G), cutting many of these off clean at the base of the stalks. Later in the season they ascend the stalk and feed on the leaves (H) till they are full grown (I) in summer. Then they burrow into the soil (A), transform to pupæ (B) from which the adults (C) emerge. The females lay their eggs (D) on grass blades. The young hatch and live on the roots of the grass in the fall (E). During the winter (F) they go deeper in the soil to hibernate till spring (G).

CUTWORMS.

There is no specific "cutworm"—the name is given to a large number of smooth-bodied caterpillars of similar habits and appearance. Dr. S. A. Forbes, the State Entomologist of Illinois, writing about cutworms in 1905, described sixteen species that attack corn in his state, though only nine were recorded as particularly harmful. Most of them are of dull colors though generally striped while some have spots. The moths are mostly grayish, yellowish or brownish with mottled wings expanding about an inch and three quarters. They all belong to the same family that includes the army worm and the corn-ear worm, called the Noctuidæ, or owl moths, being soft feathery creatures that fly only by night. Cutworms are probably best known from their habit of eating off young garden plants close to the ground in the spring—a trait which has given them their name. They do their work of destruction by night and then hide away in the daytime under any convenient board or rubbish, under loose pieces of earth or in the ground at the base of the plants. Here they may be found coiled up in a circle sleeping so innocently that the enraged gardener would scarcely suspect them of being the culprits. But they are and he need have no compunction about routing them out from their beds and destroying them on the spot. Better still, though, he should put out for them in the evenings a bait of poisoned bran-mash. This may be made as follows in large quantities and kept moist for use from day to day, or smaller amounts can be prepared in the same proportions. Thoroughly mix a pound of Paris green into 25 pounds of bran. Then make about 6 quarts of thin syrup using one part of cheap molasses and two parts of water. Grind up six lemons entire and put them in. Now stir up the poisoned bran with enough of the syrup to make a mash, dry enough to crumble in the hand but still wet enough to adhere in lumps. Scatter small amounts of this about the bases of the plants in the evenings. The worms will be attracted to the bait by the lemon but will probably hide away after eating it before they die, so you are not likely to find many that have been killed by it. Their disappearance after a short time must be taken as evidence of the effectiveness of the poison. Beware of poisoning chickens!

A few plants in a small garden can be protected from cutworms by tying collars of smooth paper about three inches high around their stems and thrust well into the ground.

The cutworms pass the winter in the ground in a partly grown condition (fig. 31, F). When spring comes they emerge (G) hungry and ready to devour any green thing that they can find, but of course this is just the time when the garden vegetables and the corn are sprouting and the tender young stalks are the first things to be attacked. A little later in the season as the plants grow some species ascend the stalks and feed on the leaves (H) and continue to do so till they are full grown by midsummer (I). Then they burrow into the ground (A), transform to the pupa (B) from which the adult moth (C) emerges. The females lay their eggs (D) usually on grass blades, after which the adults die off in the fall or when cold weather comes on. The young worms on hatching crawl down to the roots of the grass and live here during the fall (E), but they do no particular damage in the grass lands. As winter approaches they burrow deeper into the soil (F) and hibernate here till spring, when they emerge again (G) as already described to complete their growth. Most of the cutworm species are thus single brooded, though some are said to go through two or three generations during a year.

The best remedy for cutworms is that already given—the use of poisoned bran mash. There is no reason why this cannot be used on a large scale in corn fields as well as in truck gardens. Other than this the best thing that can be recommended is thorough plowing and the destruction of breeding places such as grass in the corn land.

THE TUSSOCK MOTH.*

"Are those worms going to kill the trees?"

That's what everybody in town wanted to know last summer; that is, everybody who was sufficiently interested in the welfare of our shade trees, and if it wasn't everybody it should have been.

The "worms" in question (fig. 32) were beautiful, big, furry caterpillars with bright red heads, two long feathery horns arising from the first body segment at the sides of the neck, a flowing tail of black tipped hairs held proudly aloft at an angle of forty-five degrees, and four great brushes or tussocks of white or yellow hairs carried like a crest on the front half of the back. The general color was yellowish, but the back was marked with a

*This account of the tussock moth refers to the summer of 1916.

broad blackish-brown band from the tussocks to the root of the tail, inclosing three small red knobs. These gaudy creatures were the larvæ of the tussock moth, so named from the tussocks of the caterpillars.

They were endowed with prodiguous appetities, and by the latter part of June had completely denuded many of the shade trees, especially the horse-chestnuts, transforming them from objects of beauty into pitiful straggling skeletons. By the end of the month, however the worms began to spin coccoons and soon had the trunks, branches and leaves of the trees fairly covered with their silken cases, inside of which each caterpillar changed into a pupa (fig. 34, C and D).

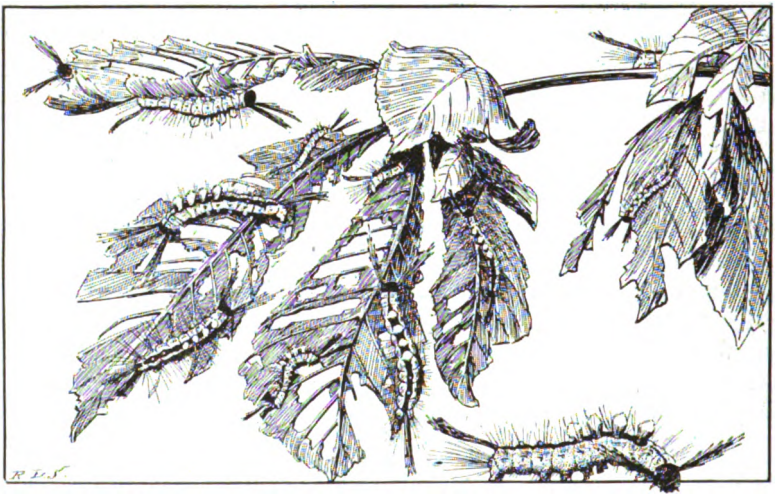

Fig. 32. – Tussock moth caterpillars on leaves of horse-chestnut.

By the end of the first week in July, six to eleven days after the pupal stage commenced, the adult moths began to issue. The males were dark, grayish little creatures (fig. 34, B) with blackish mottlings and a white spot on each front wing. On account of these white spots entomologists have called the species *leucostigma*, and, the genus being *Orgyia*, its full scientific name is *Orgyia leucostigma*. While the caterpillars of each sex are equally gaudy in their color and adornments, though the females are much larger than the males, and while the adult male is attractive, it is the adult female that surprises us. Not by her color, whoever, for she is plain, pale yellowish-white, but by the fact that she is wingless, or so nearly so as to be utterly incapable of

flight. In fact, she is a mere fluffy bag of eggs with a small head and six weak legs (fig. 34, A) that but enable her to drag herself forth from her cocoon and to surmount it, where she sits and waits the coming of the males. Then, after mating, she deposits her eggs, 300 to 400 of them, in one mass upon the cocoon or near it and covers them with a pure white, frothy-looking substance (fig. 37). After this she dies and drops to the ground, her duty ended.

The first eggs noticed last summer in Indianapolis were found on the 7th of July. They were abundant everywhere by the 19th,

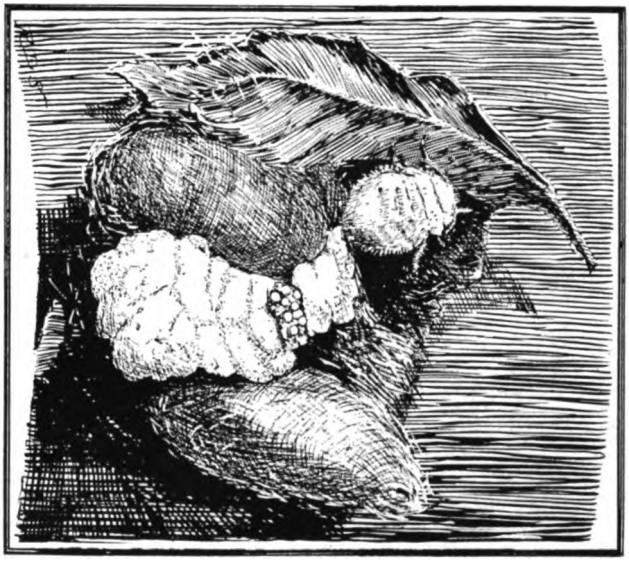

Fig. 37. – Tussock moth cocoons, adult female and egg mass.
The wingless female emerges from her cocoon, deposits her eggs on it or a neighboring cocoon, covers them with a white waxy substance, and then sits here till she dies or drops from exhaustion.

though still many caterpillars were just spinning their cocoons while some had not yet even started spinning. The earliest eggs hatched about the 19th of July, and by the 31st there were no more caterpillars of the first brood to be seen.

The caterpillars of the second generation began to be conspicious a little before the middle of August and by the 20th were again causing great devastation on the trees, being even worse perhaps in some places than the first brood. By the 26th, how-

ever, they were spinning again in great numbers, and by the 30th the majority were in their cocoons, though a few belated individuals wandered about till after the middle of September.

On September 4th the first adults of the fall brood were observed and on the 5th the first fall eggs were obtained, while the

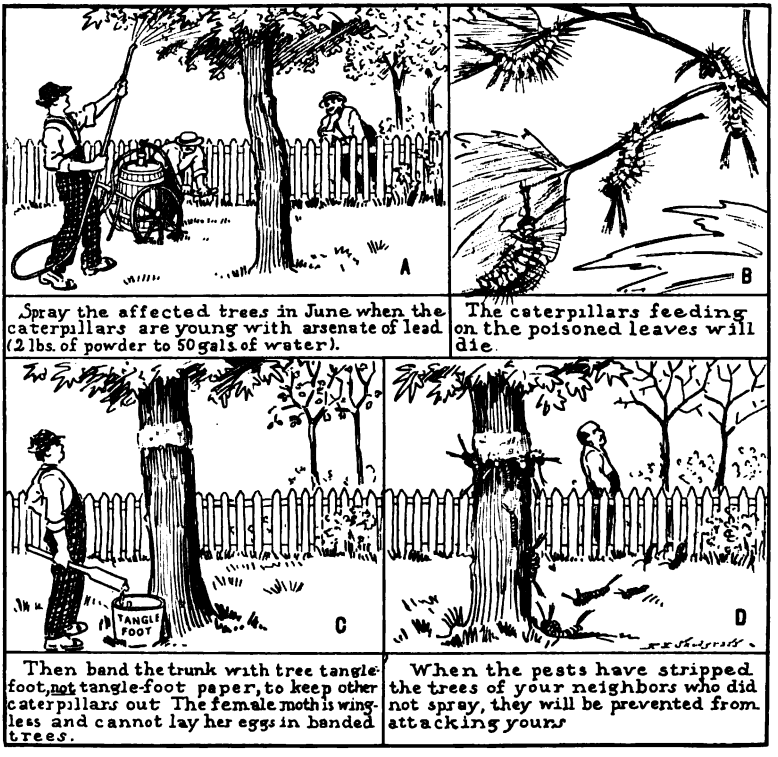

Fig. 33.—TREATMENT FOR THE TUSSOCK MOTH

laying period lasted till about the 20th. The fall eggs, however, under normal circumstances, do not hatch until the following season.

The trees that suffered most were the horse-chestnuts and after them the lindens, soft maples and elms, while the poplar, ash and willows were passed up entirely or sustained no noticeable injury.

All injury to the trees, however, was needless—arsenate of lead sprayed upon infested ones (fig. 33, A) in the middle of June and again after the first of August would have killed the pests, and the lesson of last summer should teach all who did not spray the need of doing so. Use the ordinary proportions of 4 pounds of arsenate of lead paste, or 2 pounds of the powdered form, to every 50 gallons of water. The spray should be applied all over the tree but especially to the under surface of the leaves where the caterpillars do most of their feeding.

Now, since the female moths are wingless, the only way a tree once rid of the pests can become reinfested is by the crawling caterpillars. Hence, the next problem is to keep the trees from being overrun by another lot of worms.

This problem is easily solved; encircle the trunk of the tree with a band of tanglefoot (fig. 33, C and D). Use the gluey preparation sold as *tree tanglefoot;* tanglefoot flypaper dries too soon in hot weather and becomes as hard and smooth as varnish. The other remains soft for months and needs only to be stirred up with a stick now and then if accumulating dust begins to form a crust upon its surface, while it can easily be renewed at any time. This will protect a tree from all but those caterpillars that may crawl direcly into its branches from the overlapping branches of a neighboring tree, or the very young that may be blown into it.

Great as was the damage wrought upon our shade trees by the unusual hords of tussock moths last summer, what might have happened would have been a different story yet had not a rescuing party of small insect parasites swarmed upon the invaders in such numbers as eventually to destroy three fourths or more of their great army. Some of them attacked the caterpillars direct, laying eggs upon their bodies from which hatched a maggot that bored into the creatures entrails, producing death at maturity. The great majority, however, attacked the pupæ in their cases, the females of such inserting her eggs within the pupa's body where they hatched into devouring grubs that left an empty shell of what was once a living though helpless creature. Strange warfare this but very effective since the attacking party sustains no risk.

Probably fully half of the first brood of tussocks fell victims to their enemies while more than 75 per cent of the fall generation were certainly destroyed by them. Yet enough escaped to lay many eggs for this year's hatching, and if the weather should be

propitious we cannot promise but that there will be worms a plenty to repeat the story of last year's depredations. Yet the known history of the tussock moth shows that, following years of great abundance, there have generally been several years when individuals were so scarce as to cause no appreciable damage to the trees, and it may be that history will thus repeat itself in the present instance.

A community that really wishes to rid itself of the tussock moth should, in addition to other measures, hire a squad of men or boys in the fall to pick off and destroy all egg masses accessible on the trees, on fences, under park benches or wherever they can be found. In this way a very severe check can be administered to the spring brood of the following year. But it is bad practice to destroy the parasitized cocoons. If, for appearance's sake, the trees are cleaned of all incrusting cocoons these should be put into a coarsely screened box that will retain the hatching moths and allow the parasites to escape.

Now that it is well understood the tussock moth is not a necessary evil, we may with a clear conscience admire its beauty and study more fully its interesting life and habits. The caterpillars are certainly elegant fellows,fully conscious of their gaudy liveries though in no way conceited. They move about with a measured tread, comporting themselves with a dignity becoming the heirs of a grand estate; but there is nothing of the haughty in their demeanor nor yet anything suggestive of one who does not fully believe in his rightful ownership. In these traits the tussock differs markedly from the long-haired webworm, and a study of the two caterpillars shows that these creatures have specific personalities and temperamental differences as well as structural ones. In mature life the webworms leave the homes of their youth and travel far and wide, often mingling in the same trees with the tussock caterpillars; but, in striking contrast to the latter, their manner is always of one prying and seeking, of one who pretends contempt of private ownership but who is not able to carry it off convincingly on another's property. When the tussock is disturbed he of course shows resentment, but creates no scene beneath his dignity. Touch a webworm, however, or attempt to pick one up and he flips and flops and whirls himself about in a most nasty temper and spits out a mouthful of brownish liquid at the intruder.

The young tussock caterpillars appear upon the trees in the early part of summer, infesting almost every variety more or less, but preferring the horse-chestnuts, lindens, soft maples and elms. Now a caterpillar's chief duty in life is to eat, he can truly claim that he lives to eat. In the case of the tussock species the caterpillar has to provide nourishment not only for his present needs but also for his future stages as a pupa and a moth. He fulfills the belief of those ancient pagans who provisioned the departing against starvation on their journey to the future where earthly needs would be no more. The moths take no food. No wonder then that the leaves disappear with such rapidity before a threefold appetite like this and that whole trees are soon denuded when the creatures are abundant.

Thus the caterpillars feed and fatten till they reach maturity, when the male is about three quarters of an inch in length and the female one and one fourth. Now the hitherto unrelenting appetite begins to slacken and with its departure there comes a desire to travel and to see the world. Obeying this impulse many of the caterpillars leave the tree of their birth and go to others or wander all over fences, up the sides of sheds and houses, even as high as several stories on the walls of large stone buildings. This instinct, like the appetite, serve a purpose for the species. The travel period is the time when the species distributes itself, the adult female moths being wingless and unable to walk. Yet we cannot suppose that the caterpillars themselves are impelled by any motive other than a spirit of restlessness which intervenes when their appetities no longer hold them down to constant feeding. But thus does nature accomplish her ends without letting her creatures know what she is about. It may be in the minds of the caterpillars that they are looking for a suitable place to spin the cocoons in which they are shortly to transform to pupæ, but if so they are mistaken in their choice, because the best place for the cocoons would be right in their home trees—their wanderings often take them to the most unsuitable locations such as high up on the sides of buildings where the future female moth must lay her eggs, and from whence the hatching worms must make a long and perilous journey if they are to attain their natural food. Probably most of these, as we shall see, die of slow starvation.

Whenever, at last, the desire to wander is satisfied the caterpillar selects a place for the proper construction of the cocoon and then subsides and takes a few hours rest. Soon, however, the

appointed hour arrives when the strenous labor of spinning must begin. To watch a caterpillar at this time brings us face to face with one of Nature's most impenetrable secrets. The spectacle of a lowly creature weaving an elaborate edifice the like of which it has never seen and in whose architecture it could never had had a lesson, baffles the imagination for an explanation. Of course, we call it instinct, and the word "instinct" is one of the handiest the biologist has in his whole vocabulary. Whenever an animal does something we cannot comprehend we say it acts by instinct and we are prone to use the word with a belitting sense as if to imply that the creature deserves small credit in the matter.

However, let us watch a large female caterpillar who has just begun the building of her house. For convenience of observation I confined several in pastboard boxes when I judged they were ready to begin their spinning. Out of doors they spin up most anywhere at this season, on the under sides of leaves, in a crotch between two twigs, against rough bark of the limbs and trunks, on fences, under park benches or under ledges and in cracks of sheds and houses. I have never found them on the ground or under anything lying on the ground—the instinct of the caterpillars is to go upward to find a spinning place. But wherever it is, the location must afford a floor support and at least one elevation. Hence the corner of a pasteboard box is just as good a place as any they find elsewhere.

Let us suppose now that the resting sleep is broken. The caterpillar lifts her head, feels about here and there, shifts her position a bit and presently begins to spin. What prompting she may receive we can but conjecture, and by what threats of conscience the lazy ones are goaded on to work we cannot know. Perhaps the silk-producing glands have become distended with their product and give the signal to begin. Anyhow the creature does begin, and begins a work of which we know she has no previous knowledge and of which we can scarcely believe she knows the purpose, which is no other than to provide a shelter for herself while she undergoes that change which transmutes the worm into the moth. Well, no matter what may be the thoughts of the humble worker, she follows out a plan by methods which to the beholder have nothing to distingush them from those of the skilled artisan who has painfully learned his trade and who directs each act toward an end held clearly in his mind.

Those caterpillars that I kept under observation last June always began their spinning operations after dark, and it was in

the mornings that the new cocoons were to be seen out of doors. This habit, though probably not universal, necessitated a watch throughout the night and on till the following afternoon for anyone who wished to see the process through. I must confess that I did not follow any one caterpillar clear to the finish of her work, but I can piece out a pretty reliable story from each end.

First the builder lays a silken floor on the foundation site of the future cocoon, standing upon the latter by her four abdominal legs and swinging the front half of the body regularly from side to side as the thread of silk issues from the spine-like spinneret on the under lip. The fresh silk is gummy, adhering wherever touched, and hardens at once on contact with the air. As the head is swung from side to side the thread draws out, while a touch here and a touch there gives it support and the crossing and recrossing, sideways, foreward and backward soon makes a felted sheet of closely woven thread. Thus one end of the flooring is laid and the other is done the same by a reversal of position, so in the end an oval space is covered ample to contain the body of the worker and which will serve as a gauge for the proportions of the superstructure.

The floor finished, a side wall is begun; but from now on no two workers follow exactly the same methods, even when building in exactly similar locations, such as the corners of a box, though they all arrive at the same result. Some carry a side wall up directly, supported by the neighboring elevation, which no building site may be without, then round out the ends and continue the web across the roof and down the other side till they have themselves inclosed within an oval case, closed except for a circular door always left open at one end. The caterpillar herself never comes out of the cocoon, unless forced to do so by some unnatural circumstances. The door is a provision for the future, an instinctive forsight of the builder which prompts her to construct an exit for the moth.

Other individuals first weave an outer scaffolding of threads spun in all directions, against the inside of which the walls and roof of the true cocoon are reared. Some work along continuously while others intersperse periods of labor with long resting spells when they seem to go into a stuporous sleep like that preliminary to the spinning time. Perhaps in such cases the source of the silk supply runs dry and the worker must await the arrival of more building material. Whatever the method of procedure, however, toward morning the first stage of the structure is com-

pleted—the outer case of the finished cocoon is done. But the the perfect edifice must have yet an inner chamber fitting much more snugly about the body of the occupant. In the work so far there was plenty of room for the worker, who guides her motions principally by the second and third pairs of thoracic legs while the first pair assists in manipulating the thread to give the proper contour to the walls. Within the second chamber the worker is much cramped for space, but during her labor a great change has been wrought in her—she has lost her long horns and tail, the bushy hairs of which have one by one caught in the meshes of the web and remained there so nicely imbedded in the cocoon walls as to suggest that they were deliberately extracted and used for building material. In the same way most of the long body hairs have been extracted, but the four great brushes of the back are still intact.

The outer case serves as a model and scaffolding for the construction of the inner, and when both are completed a narrow empty space is left between the two, the whole being somewhat on the plan of a thermos bottle, the inner chamber communicating with the outside by a short tubular passage connected with the rim of the original door. All this is completed sometime toward the middle of the afternnon following the evening when the work was begun, a long time if you attempt to follow the entire job from beginning to end. Now, if you are lucky enough, you may see a very entertaining sight. Pressing her head against the front end of her cell and the hind end of her body against the opposite wall, the caterpillar lifts the middle of her body, like a person about to undress in a Pullman berth, and then starts herself revolving on her long axis, turning over and over first one way and then the other as regularly as a machine; but at the same time a series of hump-like waves runs forward through her back, each one pressing the dorsal brushes against the chamber wall. The result of this combination of movements is that the bushes are rapidly ground away and their hairs worked into a felted lining against the walls of silk.

Now is the once glorious caterpillar a sorry looking thing indeed; denuded of all her adornments, her colors already fading, she retains little resemblance to the creature she once was (fig. 34, E). But the caterpillar's work is over, her life is ended, though death is not her portion, for now begins that mysterious process of reformation which will produce a moth from the dissolution of the worm. First there comes another resting

period when again the creature goes into the torpid sleep, but remains acutely sensitive to any irritation. This period lasts from twelve to twenty hours and then, in the normal course of events the second morning after spinning began, the skin suddenly splits over the top of the caterpillar's head and down the back on the first two body segments and the fully formed chrysalis or pupa is revealed within. By a violent wriggling of its body the

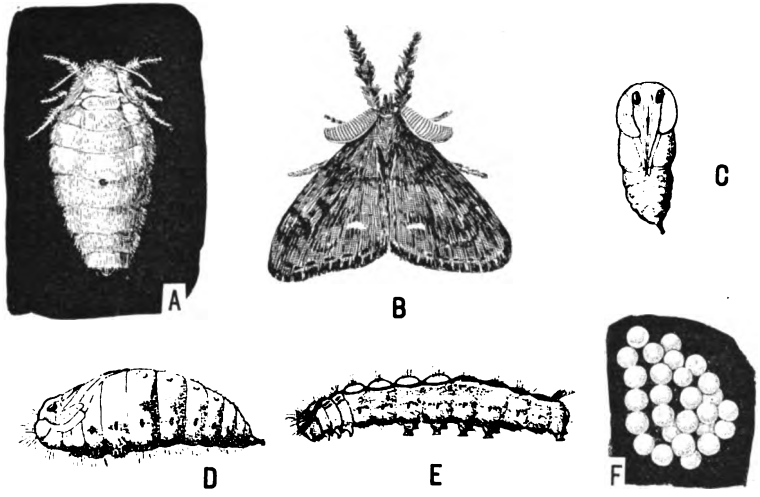

Fig. 34.—THE TUSSOCK MOTH, ENLARGED ABOUT 2 TIMES
A. adult female. B, adult male. C, male pupa. D, female pupa. E, larva denuded of its hair before pupating. F, group of eggs. (greatly enlarged).

latter now discards the larval skin, pushing it completely off in a very few minutes into the rear end of the chamber where it thereafter remains in a shrivelled wad.

The pupa (fig. 34, D) is a smooth, ovate thing with the rear end drawn out into a spine. It has no appendages of its own but the wings, legs and antennæ of the future moth are clearly marked out on its surface. At the tip of the spine on the tapering end is a cluster of tiny hooklets which soon become entangled in the fibres of the cocoon as the pupa twists and squirms, and thus the helpless creature is firmly anchored in its home. The pupa has only one duty to perform, that is to wait, but the violent wriggling, twisting and squirming which it oftens exhibits indicate that it does not pass its ten days of confinement in stoic patience.

Now, the course of nature in one creature is often checked by

something else in nature. Some of the tussock caterpillars appear to be totally exhausted after the work of spinning, the body shrinks, the color darkens, and while the power of motion is not entirely lost there is little response to any irritation as in the normal state. Sometimes this condition lasts for two or three days and then the cause of the trouble becomes apparent—a whitish maggot pokes its head from a hole in the side of the caterpillar's body and soon crawls out entirely, a fat, legless thing continually stretching and contracting as it proceeds to inspect the interior of the cocoon. The poor caterpillar is now dead, and the house it has so laboriously constructed for its own use is usurped by the parasitic worm it nurtured on its vitals. Soon the maggot settles down in a corner of the chamber and remains quiet, its skin hardens and turns dark and within twenty-four hours changes to an oval, dark-brown capsule within which the creature changes to a pupa, and from which it emerges eleven days later as a hairy fly—not an ordinary house-fly but a fly belonging to the family called Tachinidae, the members of which are mostly parasitic on other insects. The maggot which, unsuspected, was living the while in luxury within the body of the caterpillar hatched from an egg that one of these flies laid earlier in the season on the caterpillar's back. The young maggot bores at once into the victim where it feeds and grows to maturity but does not produce death in its host until after this faithful creature has spun her cocoon, which now affords protection not to the pupa of the builder but to that of the ravisher. Sometimes a caterpillar is able to transform to a pupa before the parasite matures, but the latter emerges just the same.

Should our sympathies be with the poor caterpillar thus foully imposed upon, or may we admire the cleverness of the fly who lives a life of luxury on the viscera of the caterpillar, and then enjoys the fruits of her architectural talents and her labor, spending her own pupal days in an edifice she could never have erected by efforts of her own? This is parasitism as it is usually practiced in the insect world, where nature designed one species to live at the expense of another, the incompetent parasite to be perpetuated by destroying the more gifted host. If it were not for the parasites, some pests would multiply to such an extent that we should have to give up trying to cultivate shade trees and vegetable crops. Though but a small percentage of the first brood of tussock caterpillars succumbed to the Tachinid fly last summer,

great numbers of those that went over into the pupal stage fell victims to a hord of other parasites.

The healthy pupa is at first of a pale green color, but with age the color deepens and turns brown on the back and in bands around the segmental rings. In the male (fig. 34, C), which is considerably smaller than the female and has large prominent dark eyes, the antennæ and the wing pads turn almost black as the moth within matures. From seven to eleven days after the shedding of the larval skin, if all goes well, the pupal skin breaks over the head and around the antennal and leg areas and the head of the perfect moth appears in the opening—male or female according as nature designed the individual from the beginning.

But all does not always go well from the standpoint of the species. As has already been told the pupal life is the tragic period of the tussock's history. In spite of all the elaborate care the caterpillar takes to provide for her safety in the pupal stage, the helpless creature is now attacked by a host of enemies which gain easy access to their victim through the open door of the cocoon and even through the very walls on which the caterpillar spent so much hard labor.

The healthy pupa is always active and vigorously squirms when touched or otherwise distributed, but there are many others which cannot be induced to move at all. The bodies of these are rigid, generally blackish in color though often with a transparent look. What could be the trouble? The first I discovered of this sort I examined under a lens and found that I could see through the clear spots right into the black interior. It seemed like looking into the windows of an old deserted house suspected of being haunted or of harboring thieves. And horrors! What a sight met my inquisitive gaze. The creature was actually filled, yes, packed with a gang of fat, repulsive grubs—that which was once a living body had become a dry shell full of naked worms. The tenants were so crowded they could scarcely move, but they looked so lazy that they didn't seem to care whether they could move or not. In one of the empty antennal sacs three were stretched out in plain view where now and then they slugglishly rolled their heads from side to side, but it was evident that I aroused their curiosity much less than they did mine. Every day I came back to look at the gruesome sight and soon I noticed a change coming over the wretched creatures. Their color changed from whitish to brown and on July 8 it was evident that several had changed to pupæ, while by the 14th these had trans-

formed again into tiny black winged insects. On the 17th they gnawed a hole in their prison wall and emerged into the glass tube wherein I had them confined, and a day or so later the whole crowd was out, over fifty of them in all.

The adults proved to be a little fly-like member of the order that includes the wasps and bees and all other stinging insects called the Hymenoptera, and to belong to the notoriously parasitic family of Chalcididae. The species, as far as I could tell, is the common *Dibrachys boucheanus* (the species being much more common than its name), though other writers have described it only as a parasite of other parasites. An examination of other pupæ revealed great numbers of them parasitised by these little creatures, in one large female I found one hundred and fifty-two of the grubs (fig. 35, A).

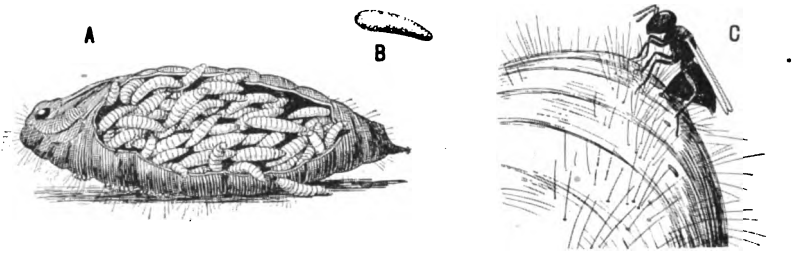

Fig. 35.—A PARASITE OF THE TUSSOCK MOTH PUPA, GREATLY ENLARGED

A, female tussock pupa filled with the parasitic larvae. B, an egg of the parasite. C, the female parasite ovipositing through a spiracle.

The adult parasites (fig. 36, A) were very numerous out of doors on the trees where they could be seen running about over the bark or found hiding in crevices, while frequently they might be surprised within the tussock cocoon which they freely entered by the front door. I captured several of them in vials and took them into the office for observation, supplying them with fresh tussock pupæ in the hope that they would give me a demonstration of how they insert their eggs, and this they did very accommodatingly. The tussock pupa is of huge bulk compared with the little parasite and is incased in plate armour that would seem proof against any weapon of such tiny assailants. Yet the latter must somehow get their eggs within the pupa's body, else how do the grubs come to be there? The female parasite, however, has no doubt of her ability. With quivering antennæ and in a spirit of feversish excitement she runs all over the helpless

giant, probing now here now there with a sword she carries slung lengthwise in a sheath beneath her body. The point of this weapon projects at the tip of her abdomen between two little finger-like appendages. With these she selects a likely spot, inserts the point, and then backs up against the sword which now turns downward on its hinged base and stands vertically beneath the abdomen of the executioner, while the latter bears down on it with all her strength. Still perhaps the blade won't penetrate the tough integument. No matter, some other place is weaker, the parasite knows it is her business to puncture that cuirass and she keeps at it till she does. A dozen more attempts may be made without success, and then by chance the next probing strikes a weak spot, when in goes the sword, deeper and deeper it sinks, till at last it is fairly up to the hilt. Now the parasite assumes a curious position, she raises herself vertically, propped up on her hind legs, the others dangling in the air, so that all her weight comes to rest upon the buried weapon. The antennæ cease their movements and for hours hereafter there is no motion but the regular contractions of the abdomen as it forces out the eggs.

Here we must pause to explain that the sword-like weapon with which the parasite thus deliberately and in cold blood assaults her helpless victim is properly called the *ovipositor*. This signifies that it is primarily an egg-laying instrument. In order to serve as such it is composed really of three blades which fit close together lengthwise, so close that they can be used as one for stabbing and puncturing; but, once in the wound, the blades relax and open a passageway between them through which the parasite inserts her eggs into the body of her victim.

All the while that the egg-laying operation is in progress the great helpless pupa writhes and squirms and rolls, but the parasite sits tight regardless of all danger to herself. You can pick up the pupa and examine the procedure at your leisure, turn it about, put it under a microscope, but the parasite is unconcerned—naught else matters to her now but the deposition of her eggs.

Often while probing about for an insertion point the parasite discovers the porous area on the pupa's back covered by numbers of soft tubercles offering an easy entrance to the ovipositor, and sometimes one is luckey enough to hit upon a spiracle or breathing pore, as did the one shown at C of figure 35 after probing about for a whole hour without success in gaining an entrance for her instrument. After the egg-laying operation is finished

(and it lasts often several hours) the pupa is left rigid and motionless, inert but not dead, a capsule of living matter for the future grubs to fatten on.

The female shown at C of figure 35, ovipositing through a spiracle, was the first that I observed in the act and of course I was eager to prove the deed against her by discovering the eggs. She had finally settled to her work about 8:30 in the evening and, after watching her for an hour, I made note of the particular spiracle and went home. Next morning the parasite was off and apparently finished with her job. The pupa was rigid, to all appearances dead. I carefully cut away the part of its body-wall containing the punctured spiracle, and—there were the eggs—only a few of them, and the minutest things imaginable, but beautiful little objects, floating in a group on the creamy vitals of the pupa directly beneath where the ovipositor had been inserted. The lancet had undoubtedly punctured the trachael tube within the spiracle. I lifted one egg out on the tip of a fine needle and made the drawing shown at B of figure 37. The egg measured two fifths of a millimetre in length (about 1-60 of an inch), was slightly curved and a little larger at one end than the other. The other eggs I left in place but the exposed viscera dried and they did not hatch. However, by opening other pupæ I could get hundreds and thousands of the grubs in all stages of development.

The insides of a pupa constitute one of the curious things in nature. They consist of a yellowish, oily cream formed from the dissolution of the larval organs; but this matter is still alive, being areated by the great masses of breathing tubes which are still intact, and contains the power of regenerating the insect into the adult form.

The eggs of the parasitic Dibrachys float on the surface of this substance till they hatch, and the minute grubs thus find themselves at birth surrounded by a rich, predigested, semi-liquid food, with nothing else to do but to imbide it and grow. It is disgusting to contemplate a creature in this yolk-like stage being helplessly devoured internally by a gang of greedy grubs, yet there is nothing vile to the senses, nothing putrid, nothing dead. It is simply a process of life transference from one large creature to many smaller ones. The parasitic larvæ swim lazily about in their diminishing lake of living food with slow sidewise undulations of the body, or lie stretched out perfectly quiet and contented on its glistening surface. When many are

present the pupal contents will be entirely consumed, but where there are only a few a plug of dried matter is left at one end or in the middle. Several adults will oviposit in the same pupa when confined in a vial and probably do so in nature, because the greatest number of parasites I reared from any one parent was 20, while it is common to find 50 to 100 grubs in large pupæ and even more, 152 being the most that I ever counted. The larvæ pupate without spinning cocoons and when the adults emerge they gnaw a hole in the pupal wall through which they gain access to the outer world. From three tussock pupæ on which oviposition was observed the adult parasites emerged in 21, 22 and 36 days respectivelv after the laying of the eggs.

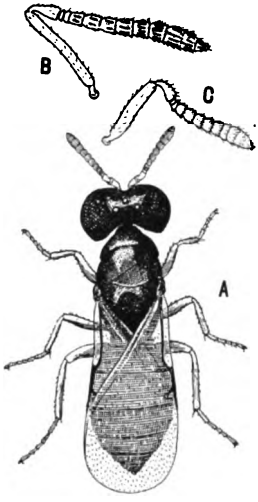

Fig. 36.—*Dibrachys boucheanus*, parasite, enlarged 20 times.
A, adult female. B, antenna of female, more enlarged. C, antenna of male.

The adults of *Dibrachys boucheanus* (fig. 36, A) are active little creatures quite different in temperament from their sluggish larvæ. The female is larger than the male and the sexes differ in the character of their antennæ as shown at B and C of the figure. Each has two pairs of wings which ordinarily they keep folded flat on the back. They flit about when disturbed with short flights that look like flea hops. The females are very quarrelsome amongst one another and if several are confined together in a vial there is likely soon to be a battle royal on, usually resulting in the total disability of one or more of the combatants, the loss of legs and antennæ by others, while it is seldom even the victor escapes without some slight mutilation. Females greatly exceed the males in numbers in all that I reared, but the males are very fickle in their affections and practice polygamy as a matter of course. In courting, the male sits on the female's back and he readily skips from one to another as the fancy takes him.

The adult females feed on the juices of the tussock pupa as well as do their offspring. Often you will think that you are about to witness an ovipositing performance and find yourself mistaken. The parasite has pierced the pupal shell and has buried her ovipositor full length in the squirming victim, but immediately she

extracts the blade and allows it to flip back into its sheath beneath her body. Then she backs up a couple of paces, applies her mouth to the bleeding puncture and proceeds to lap up the exuding juices with much relish though her meal often occupies the greater part of an hour. The males of course, having no swords, cannot get food in this manner and I know nothing of their feeding habits.

The species passes the winter as full grown hibernating larvæ within tussock pupæ that did not transform in the fall owing to the presence of the parasites.

Parasites themselves have parasites and the parasites of parasites have parasites. This may not be "ad infinitum" but it is enough to complicate the parasite problem quite sufficiently. The first parasite in the series is called a *primary parasite* and the others are called *secondary* and *tertiary* parasites or *hyperparasites*. For example *Dibrachys boucheanus* lives as a parasite also in the cocoons of other parasites of the tussock moth, which places it in the hyperparasitic class. But the evidence here presented shows that this same *Dibrachys* is a most important primary parasite of the tussock pupa, if I have identified the species rightly, though other authors have listed it as a hyperparasite only. Moreover, I reared eleven specimens from larvæ that had issued from a tussock caterpillar after the latter had spun its cocoon, showing that it does not even confine itself to pupæ. This case shows also the remarkable adaptability of the species to circumstances, for whereas it may safely remain in the pupa until the adult stage, the larvæ seem to know that a caterpillar is no fit place in which to undergo its transformations.

Three other species of parasites belonging to the family Chalcididæ were reared from the summer brood of tussock pupæ. One was very similar to *Dibrachys boucheanus* though larger and was often found in the same pupæ with the smaller species; the second, also a small species, was reared from only one pupa; the third, a much larger species, known as *Chalcis ovata* was very common and only one grub lives in each infested pupa. Altogether at least 50 per cent of the first brood of tussock moths were destroyed by parasites.

The adult male of the tussock moth is shown at B of figure 34 in the attitude he assumes when at rest. Being of a nocturnal disposition he sits around on the trees most of the day with his antennæ and wings folded back against his body and his long bushy front legs extended out in front. He has no jaws and his

other mouth-parts are so very small and weak that it is probable he takes no food at all. When he first crawls out of his coccon he does not have that trim appearance; on the contrary, he has the disheveled look of one who has passed the night in his clothes, and a very bad night at that—his wings are all crumpled and he staggers around in rather an uncertain manner. Soon, however, the wings expand and straighten, the legs become steady and the new arrival is ready for his short fling at life.

The adult female (fig. 34, A), is a curious, fat, little creature covered with a soft coat of creamy white fur. Her body is considerably larger than that of the male but her wings are mere flaps on the sides of the thorax, rendering her totally incapable of flight, while so weak are her legs that she is able only to drag herself out of her cocoon and up on top of it where she waits for the males to find her in their courting excursions after dark. Like the male the female has very rudimentary mouth parts and food is something she knows not of unless some vague memory persists from the caterpillar stage. Her abdomen is crammed full of eggs and these she must retain until she receives the fertilizing element from a male.

The marriage ceremony is probably performed in secret under the canopy of night for I have never been a witness of it. Others however, have observed that one female often attracts a large number of suitors who may be seen hovering about her on the wing. But since there are no bride's maids at this ceremony to satisfy the disappointed ones the latter probably with good grace fly off to try their luck with Aphrodite elsewhere, whenever the first female has selected her approved mate. Certain it is that few of the females are left to spinsterhood, for every morning during the coming out season each one newly arrived over night is already a shrunken matron with a great mass of eggs spread out behind her. All are safely tucked beneath a glistening sheet of pure white waxy stuff like frosting on a cake, frothy in appearance and full of bubbles, yet tough and durable, impervious to rain, tasteless and probably unattractive to birds and to other insects. This egg-covering, formed by glands within the body of the female, more resembles wax than silk. It is readily dissolved by caustic but is only macerated by acid. It is entirely insoluable in water even when boiled. Silk on the other hand is quickly dissolved by acid but is only macerated by caustic.

Each egg mass (fig. 37) contains from 300 to 400 spherical eggs (fig. 34, F), of a pale greenish-white color. The easiest way

to count them is to put the entire mass in a dish of caustic soda. This quickly dissolves the protecting and cementing substances and liberates the individual eggs.

If a female is forced by imprisonment into involuntary virginity she never parts with her eggs, or at most with but a small proportion of them. Even in death she clings to them and her drying body shrinks to a transparent sack still protecting the object of her existence, of the pupa's transformations, of the caterpillar's life of ravenous destruction. The normal, fertilized female lives a few days after she lays her eggs, then dies a gradual death and drops from her cocoon, a discarded and useless thing returning to the elements.

Last summer in Indianapolis the first moths of the summer brood appeared about the 19th of July, and at this season most of the eggs hatch within ten or eleven days though others require as much as twenty-six to thirty-one days. The same discrepancy is to be observed in the spinning dates of the caterpillars For a week after the first larvæ of the second brood hatch there are still caterpillars of the first brood crawling and spinning. Hence there is no time throughout the summer when the trees are not being attacked by caterpillars of either one brood or the other or by both.

The traveling habits of the mature caterpillars, which, as already pointed out, bring about the dispersal of the species, result in some curious miscalculations on the part of nature. If the female caterpillar of the first brood selects a spinning site on the leaves or any part of the tree, well and good; but suppose she crawls up on the side of a house or other building, at this same place must the future moth deposit her eggs—and then what of the little caterpillars that hatch from them? Will they have strength and intelligence sufficient to crawl down from their high birth place, cross intervening lawns, sidewalks or roads and then go up some tree on which they can obtain their proper food? This is asking much of such weak creatures.

The infant tussocks (fig. 38) are "cute little things" like all babies. They are about one sixteenth of an inch in length, very woolly, with hairs in front and behind half again as long as the body. They can probably be blown about very easily by the wind. At each side of the first segment behind the head is a small knob carrying a bunch of long spreading hairs but none of the characteristic ones of the future bushy horns. The color is

pale yellowish with two brown stripes along the sides of the back and broken bands between them. The head is yellowish-brown.

Supposing now that these little caterpillars do somehow or other find their way to earth from the side of a building or any other arid region of high elevation, how can they ever traverse a wide lawn or a field of weeds and coarse grass to arrive at the nearest tree, as they would often have to do? Perhaps they could live by the way feeding on whatever vegetation came to hand. To test this possibility I placed a hatching family on some potted lawn grass where I could keep them under observation. The result was that none of them could be induced to eat the grass. Few of them would even venture on it, so I distributed a dozen or so about the grass blades with a soft brush, but never a one would deign to eat of it. Other observations showed that the larvæ greedily attack maple leaves when only twenty-four hours old, but those on the grass persistently refused to regard it as food—they all wandered off and starved. After ten days I considered my forcible feeding experiment a failure and concluded that, to the little tree-loving caterpillars, a journey across a wide, green lawn would be about the same as a trip across the Sahara desert.

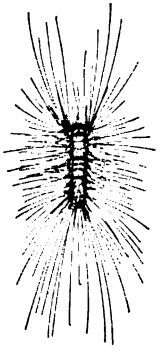

Fig. 38. — YOUNG TUSSOCK CATERPILLAR (enlarged about 6 times.)

How long can the newly hatched caterpillars live without food? Most of them starve in four days, though a few live over to the fifth, when confined in the dark, but they are too weak to walk much after the third day. This answer I obtained by keeping fifteen of them in a small box. Crawling around in the open they would be more quickly reduced by starvation. But in nature they do not need to find food at once on hatching—they can live indefinitely on the frothy covering of the eggs, for they eat holes all through this substance and many of the old egg masses are honeycombed by the broods that issue from them. While the stuff is insoluble to us it may be that the caterpillars' saliva is more alkaline than ours.

One warm afternoon I placed ten young larvæ that had not yet been away from their egg mass on the side of a wooden house above the level of a second story porch where I could easily observe them. The side of a house must be a pretty big place to creatures of their size and if they have any "sense of direction"

to the nearest tree I thought it would be interesting to see it work. But it didn't work, at least it wouldn't on the house. Some of the larvæ crawled slowly about in various directions though most of them soon stopped beneath an overlap of the boards. At the end of an hour and a half none had gotten anywhere, and the one that travelled the most was scarcely six inches from the starting point.

Now observe what different results the next experiment gave. I placed about a dozen new-hatched larvæ on the trunk of a small soft maple tree. Activity began at once. Two started straight upward, stopping for nothing. Then a third set out in the same direction and soon there was a race with two in the lead. The two leaders covered nine inches in the first five minutes, then one of them stopped to scratch his back, forgot his hold, and the wind blew him away. The other continued and covered ten inches in the next five minutes and six more in the next. Already he was at the base of the first limb, having climbed twenty-five inches in just fifteen minutes. Now the third had overtaken him, but here the two chose separate roads, the first going out on the first limb while the other continued upward along the main trunk and out on the next limb above. In half an hour the second was forty-one inches from the starting point. After this I lost sight of both but I do not doubt they had their suppers before night came on, for the distance yet to the nearest foliage was less than half of that which either had already traversed. Looking back along the trunk I discovered a third that was up to the end of the first limb and still going; several others were part way up, but the rest were lazily tucked away beneath edges of the bark near where I first placed them.

The bark of the tree was rough and the travellers had to get over all kinds of irregularities, to cross fissures, and to go around frequent crevices. Every now and then one had to retrace his steps on finding himself at the tip of a projecting piece of bark, but nothing effaced for a moment from their minds the idea that their course was upward.

Thinking now that I had perhaps put a particularly lazy lot out on the side of the house I transferred six of these, which had scarcely moved in two hours, to the trunk of the maple. Immediately they were wide awake and as active as the others. Three were caught by the wind and carried off, while the other three started upward at once. I did not follow them as far as the other but they were still going when I left.

Well now, what do you say to that? But it really isn't necessary to say anything—the little caterpillars by their actions speak louder than words. They know at once when they are on a tree, and then what to do and where to go. Some, perhaps, were not hungry yet, but notice that not one of them went downward.

The apparent results of these experiments seemed so remarkable that I felt some farther trials would make conclusions safer, so one afternoon a few days later I put five young larvæ, hatched the same day, on the trunk of a linden about three feet above the ground. A chyrsopa larva, one of those dragons of the insect world, happened along just at this moment and snapped up one of them. The other four remained quiet for a time, then after a while one started upward and had traveled twenty-seven inches within forty-five minutes from time I put them out, but the other three had not yet moved.

Thinking that these larvæ were perhaps to young to travel yet, I waited until the following morning, when they were over twenty-four hours old, and then put ten others on the truuk of the linden about five feet from the ground. Three were blown off immediately by the wind, three started upward and four sought refuge in crevices of the bark. Ten minutes afterwards a fourth came out of its resting place and started up, while five minutes later a fifth became restless and began the upward pilgrimage, leaving but two slothful ones below. The five continued their progress upward, the leader covering twenty-one inches in the first fifteen minutes.

Observe still that *none went downward.* From these experiments I conclude that there is no need to worry about those cocoons on the sheds and houses, or even those on fences where trees are not readily accessible. Most of the larvæ that hatch from eggs laid by the moths from these must automatically perish. The instinct of the new-hatched creatures to go upward can only lead them farther from the source of life unless the course of their ascent leads on to foliage at last. Hence, the more caterpillars that spin on the sides of buildings the better. Last summer the south end of State House in Indianapolis was covered with cocoons. The thoughtless caterpillars had spun them everywhere about the doors and windows, under ledges and in the crevices between the stones of the first and second stories above the basement. During the laying season hundreds of the white egg masses could be seen, but if the hatching larvæ went anywhere

they probably ended their careers upon the dome unless some pitying wind carried them off and landed them safely in a tree.

This habit of the caterpillars which must lead to such a large percentage of infant mortality is an example of the defect of instinct. Instinct never provides for emergencies or changing circumstances. It is perfect for the conditions for which it was created. In primitive nature it was all very well for the mature caterpillars to wander about at will and to go upon any thing that strikes their fancy at the spinning time, for then almost every vertical surface would be the trunk of a tree. A few might come to grief on rocks and cliffs. But in the environment of human civilization there are everywhere to be encountered walls of buildings, fence posts, lamp posts, telegraph poles and upright things of all kinds, so an instinct that simply says "go up" without qualification as to what sort of thing shall be ascended must lead the unsuspecting caterpillar into very disastrous situations for her progeny. If nature had been a little more liberal in the distribution of reasoning faculties things like this would not so often happen. However, it is to our advantage in this case, for it lessens by just so many the number of the pests for us to combat.

As before stated the first summer eggs begin to hatch about the 19th of July, nine to eleven days from the date of laying. The young worms do not all emerge from any one lot at the same time, but continue to come out a few every day for as long as two weeks, though the majority will have issued by the end of the first week. This difference of incubation period, varying from nine to twenty-three days in observed cases, has nothing to do with the age of the fertilized eggs for they are all laid during one night by the parent moth.

The newly hatched caterpillars spend most of the first day day sitting quietly about on the white covering of their eggs, gnawing at it now and then as if eating it. A few venture away for an inch or two on the surrounding surface, but it is not till the second day that they spread to the leaves, if their home is in a tree, and begin feeding on them. Those observed collected in groups generally at the base of a leaf on the underside and worked outward, eating off only the epidermis at first, though it was not long till they were making perforations and eating out the entire thickness of the leaf. At this stage they spin silk threads by means of which they disperse themselves rapidly over a cluster of twigs or leaves like tiny acrobats, but none that I kept under

observation did this until after they had fed a little on the leaves. The larvæ of one lot kept on linden leaves moulted within the first three days. In the second stage they showed distinctly more of the tussock character, having short horns and stubby tails of black-tipped hairs, but the body was still covered with long hairs and showed no signs of the brushes on the back. They moult at least once more before becoming full-grown.

The second brood of larvæ lives the same life as the first and individuals begin to mature toward the last week in August. By the 26th last summer they were spinning in great numbers. Many complaints now came into the office of porches, screens and houses literally overrun by the pests. In some places the trunks of trees were plastered thick with their cocoons, and great masses of the latter were to be found under benches in the parks and in any nook or crevice that offered protection on fences and buildings. Very few, however, spun their cocoons this time on the leaves of the trees, though many were on the branches and twigs where a leaf might lie in contact, and this was a wise forsight, for had the caterpillars at this season spun upon the foliage great numbers of the future eggs would have been lost with the falling of the leaves.

Watching the cocoon-spinning of this brood gave me the impression that the work was rather careless compared with that of the earlier brood. Many of the cases, especially those of the males were but flimsy affairs when completed, and work was begun at any time during the day or night. My records give seven to nine days as the length of the pupal stage for this brood. Then again the adult males and females began to appear on the scene and soon trees, fences and building were once more flaked with the white egg masses. These eggs, however, are destined to weather out the winter storms and to remain fresh until the following spring when they will supply the crop of next year's caterpillars.

While these were eggs a plenty in the fall, yet an examination of cocoons showed that great numbers of the pupæ had again been killed apparently by parasites—certainly 75 per cent and in some localities at least 90 per cent could never yield a moth. Thus out of 226 cocoons of the fall brood collected in St. Clair Park on September 19th, but 14 contained healthy pupæ. Over the same territory 24 fresh egg masses were obtained, but no count was made of cocoons from which the moths had emerged.

In the fall brood of pupæ another parasite showed up in con-

siderable numbers that we did not get in the summer lot. This was a species of the genus *Pimpla*, probably *Pimpla inquisitor*. The adult is a slender wasp-like creature, the female with a long ovipositor by means of which she punctures the cocoons and lays her eggs on the caterpillar before the latter has transformed to a pupa. The larvæ feed on the caterpillar and when full grown spin a mass of their own cocoons within the tussock cocoon. Many specimens were hatched from these during the middle of September. The two common parasites of the earlier brood were also the most abundant now, but in addition three other species were obtained in small numbers. Hence we have a record for the entire season of eight parasitic species of Hymenoptera and one fly as allies in holding down the numbers of the tussock moths.

A few other enemies not classed as parasites helped in the work. The caterpillars are said to be eaten by those birds that do not mind hairs in their food. A species of bug belonging to the family *Pentatomidæ* having a long thick beak attacked both the larvæ and pupæ, sapping them alive. Chrysopa larvæ probably destroy many of the newly hatched caterpillars. A "wilt" disease attacked a few caterpillars last summer and a few were seen reduced to helplessness by a sudden diarrhea. Yet with all these things leagued against it the species was able to leave a goodly showing of eggs for next year's brood.

The status of any species is usually to be regarded as a balance between its own generative forces and the destructive forces of its enemies, but the weather must be counted in as playing a very important role in causing fluctuations from year to year. A very favorable season sometimes enables a species to get ahead of its parasites, but its very increase is in return beneficial to the latter and is shortly followed by their multiplication. Then this causes a reaction against the host species which may reduce it for a while below the average normal. Hence it is that we often see a year of great abundance for some pest followed by a year of more than usual scarcity.

Any one widely spread species is not necessarily checked all over the country by the same enemies. In 1897 Dr. L. O. Howard of the U. S. Bureau of Entomology made a very thorough study on the parasites of the tussock moth in the District of Columbia. Altogether he listed twenty-one parasites, with *Pimpla inquisitor* as the most abundant and important and *Chalcis ovata* next in numbers. Now, in our studies of the tussock parasites in Indianapolis last summer we found the tiny *Dibrachys boucheanus*

greatly in excess of all other species, while Dr. Howard lists it only as a hyperparasite, i. e., a parasite of the other parasites and hence friendly to the tussock. *Chalcis ovata* was next in importance in our material, followed by *Pimpla inquisitor* and the Tachinid fly. The other five species were of small consequence.

Even a brief study of a species like the tussock moth shows us that the life of any creature in nature is fraught with hazards on every side. The chance that any particular individual will leave progeny is always less than the chance that it will fall a prey to one or more of its numerous enemies. Hence the enormous rate of reproduction given to most insect species—the lucky few must make good the losses of the many. In numbers only is there assurances of perpetuation.

The description of the tussock moth and its parasites here given is based on observations made on a limited number of specimens during only one season; and, as often happens, the study of a greater number of specimens during a number of seasons may show that some of the traits recorded are exceptional and that the general truth is, in some cases, different from that which appears to be indicated by a few facts. Hence, the reader is requested not to infer that the writer intends this account to be taken as a finished story. The observations are given for their individual worth. Perhaps this year we shall find other traits prevailing, other parasites predominant, and various changes made in the schedule to fit a different sort of season.

FLIES

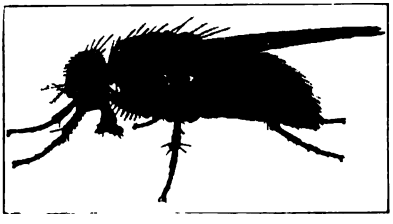

Fig. 39.—THE HOUSE FLY

The common flies of our houses are an ever present menace to our health during the season when they are about. They carry the germs of typhoid fever, tuberculosis and other diseases on their feet and bodies and in their digestive tracts.

They contaminate foods exposed to them with the germs of these diseases.

Their breeding places should be discovered and the flies prevented from gaining access to them. This is the only effective way of decreasing the number of flies. The sources from which they collect disease germs should be closed against them. Flies are not dangerous unless they have become themselves contaminated with disease. All food should be protected from them. The germs of typhoid fever and of other diseases carried by flies enter the human system by way of the alimentary canal.

The principal breeding place of flies is fresh manure, chiefly horse manure, and this may often be found teeming with thousands of small, active, whitish maggots, which are mostly the larvæ of house flies (fig. 45, A). Even small neglected piles of manure along the streets will quickly become infested with great numbers of the maggots, which will change to adult flies in less than two weeks during the summer if the street cleaner is careless about his work.

Some people still ask if flies are generated by the heat and decomposition of the manure. No, they are not. An adult fly must lay her eggs there in order to produce the maggots. Flies cannot come from a pile of manure without the eggs being first deposited in it, any more than chickens can come from a hen coop unless some hen laid her eggs there. The manure pile simply acts as an incubator and furnishes the larvæ with their food after hatching.

The first step, then, in any fight against flies must be the prevention of flies from access to stable manure, or the treatment of the manure with some chemical that will destroy the maggots, if they have already been allowed to breed in it.

The adult female fly lays from 25 to nearly 100 eggs at a time, according to the most authentic records, those of the U. S. Bureau of Entomology, and she lays at least twice during her lifetime. The eggs (fig. 45, B) hatch in less than twenty-four hours, during warm, moist weather in eight or ten hours, giving birth to tiny, transparent, legless maggots. These grow rapidly, and in midsummer, reach maturity in from four to five days if they have plenty of food. The full grown maggot (C) is about half an inch long, and of a yellowish-white color. The front end tapers to the tubular head, and the body is divided by rings into twelve or possibly thirteen segments, since the first behind the head is indistinctly double. The front edge of each segment, especially

those of the posterior half, is thickened below in to transverse pad covered with minute points. These pads serve the creature instead of legs. The last segment is the largest and bears two prominent, dark eye-like spots on the upper part of its terminal surface (C and E, *b*). These are not eyes, however, but breathing plates, for each contains perforations which open into the large air tubes within the body. Two smaller, ear-like, breathing organs (C, *f*) are located on the sides of the body, a short distance behind the head. From the mouth, which has two little fleshy

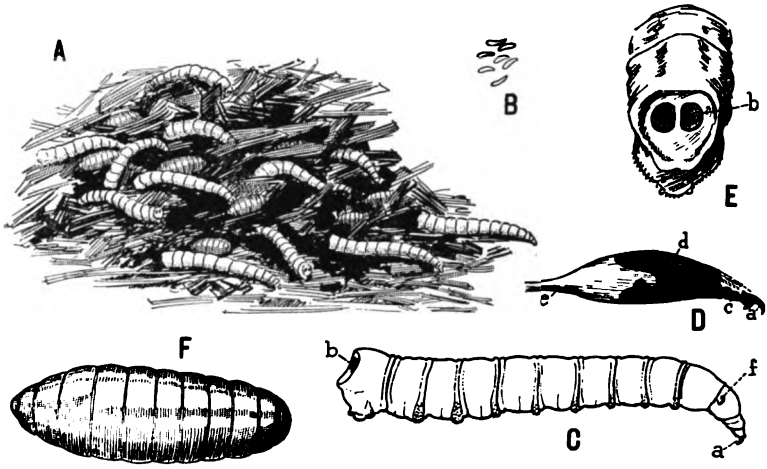

Fig. 40.—THE HOUSE FLY, LARVAL AND PUPAL STAGES

A, maggots and puparia in manure. B, eggs. C, full-grown maggot, enlarged about 5 times: *a*, mouth hook; *b*, spiracles at near end of body; *f*, ear-like spiracles on front end of body. D, the pharynx or throat of the larva, greatly enlarged, showing the mouth hook, (*a*) and the plates (*c* and *d*) that support it; *e*, œsophagus. E, rear end of the body showing the posterior spiracles (*b*). F, puparium.

lobes on its lips, there can be protruded a strong, black hook (C, *a*). This is fastened to a small plate on the floor of the mouth (D, *c*), which in turn is connected with two large plates (*d*), that flare up around the side walls of the throat. Muscles are attached to the plates and to the base of the hook itself, by which the hook is thrust out or pulled back into the mouth.

In life the maggots are sleek, smooth, shiny creatures with the segmental rings showing but indistinctly. The rear end with the large breathing plates is tensely rounded and glistening. It is only specimens contracted from being preserved in alcohol that have the structural characters exaggerated as in the drawing. The contents of the alimentary canal show black in the rear half

of the body and the beautifully branching forms of the breathing tubes, glistening white with the air they contain, contrast strongly against the dark. Along the back the rapid pulsations of the heart are visible and the foreward part of the alimentary tract is in constant peristaltic action.

The maggots are restless creatures, forever in motion, crawling, writhing, thrusting the head now here now there, impelled by a relentless appetite, always seeking the wherewithal to glut their ravenous maws. Locomotion is principally by means of the segmental foot pads and the stretching out and pulling together of the body, but the mouth hook plays a very important part. By means of it the creature grabs hold of bits of solid material with a vigorous thrust of the head, and then pulls up its worm-like body. On a smooth inclined surface like one of glass or tin the maggot is almost helpless unless moistened, when it glides with ease and rapidly in any direction even on vertical walls of glass. In such cases its grappling hook of course is useless, but I studied one beneath the microscope, travelling over a moistened piece of white cardboard, and while the motion is almost too rapid for observation, I often caught glimpses of the hook protruded with the foreward thrust of the head end of the body. In their natural environment it is seldom possible to see just how the larvæ use this organ, so desperately restless and energetic are their motions, but they grapple with and momentarily cling to any bit that gives a solid anchorage in their wild endeavor to seek out the juicy spots that furnish for a second some abatement to their burning thirst. Having no true jaws they probably do not eat dry solid matter.

I observed one holding a disgusting feast on the entrails of a dead comrade. The scavenger had its head and fore parts buried almost up to the ear-like breathing lobes in a hole which I do not doubt it had clawed through the side of the corpse. Violently it plunged and retracted like a living piston, seemingly insane with gluttony. I forced it away from its repulsive fare but rapidly it turned and lapped up the exuding vileness, and then once more began its frantic plunging into the festering hole. I had seen enough—there are more beautiful things to contemplate in nature than the maggot of the fly.

The larva is said to moult its skin twice during its growth, and in cool or dry weather or when its food is deficient it may take much longer than five days for it to reach maturity, but when it is full grown it crawls down to the bottom of the manure pile near the

outer edge or into the ground beneath it or even some distance away and there changes to a pupa without shedding its skin. The last larval skin shrinks and hardens into a dark reddish-brown capsule called a *puparium* (fig. 45, F). Inside of this the pupa (fig. 4) becomes an adult fly within four or five days during the summer, and when the adult is ready to emerge it extrudes a little sac from the front of its head which breaks open the end of the puparium, forming an opening through which the adult fly then makes its escape. The sac is now drawn back into the head, the hole in the face closes, the skin hardens, the wings unfold and the creatures quickly assumes the form of a normal fly. After this it grows no more, though all flies are not of the same size—the males are smaller than the females, and both sexes will be undersized if the larval food has been deficient.

In cities there is no excuse for allowing flies to breed. Preventive measures such as the following, recommended by the Indiana State Board of Health, should be adopted and enforced by all towns and cities: "All stables or barns, or other shelter wherein animals are kept, shall be cleaned daily in the months of April, May, June, July, August and September, and all manure shall be daily taken away or kept in dark, water-tight, fly-tight bins, pits, or boxes, which shall be emptied and the manure taken away when full, or, when ordered in writing by the health officer or marshal."

In the country such means may not be practicable, but certainly every farm family would welcome a relief from flies.

The U. S. Bureau of Entomology has carried out experiments with a long list of chemicals to discover a suitable poison for the treatment of manure which will kill the fly maggots in it and at the same time not destroy its fertilizing properties or produce any injury to crops on which it may be used. In Farmers' Bulletin No. 679, July 14th, 1915, Dr. L. O. Howard and Mr. R. H. Hutchinson, recommend, as the final result of these experiments, the use of powdered hellebore as follows: Make up a stock solution in water in the proportion of ½ pound of the powder to every 10 gallons of water, stir the solution well and let it stand for 24 hours before using. Sprinkle 10 gallons of this stock mixture over every 8 bushels (10 cubic feet) of the manure to be treated. This was found to kill from 88 to 99 per cent of the fly larvæ. Used in smaller quantity it is not so effective while a more liberal dose will be surer of effects. Hellebore costs from 12 to 16 cents a pound but can be obtained in large lots for 10

cents a pound or less. The cost of the treatment will amount to a little over one cent for every two bushels of manure. Hellebore is not injurious to any plants, and since it contains at least one per cent of nitrogen it may be positively beneficial to the soil. Care should, of course, be taken not to leave the hellebore solution standing uncovered where any farm animals might have access to it for it is a deadly poison. Chickens, however, are not injured by picking at treated manure, because they cannot possibly eat a large enough amount of it in this way to harm them.

Borax is a stronger larvicide than hellebore but is harmful to some plants so its use on manure is not to be recommended, but it is most valuable as a maggot exterminator on anything else than manure.

Finally, the greatest danger from flies is due to their habit of frequenting human excrement wherever it is accessible to them in open closets such as are used in the country and in all towns where plumbing is not universal. These closets are the principal sources from which flies gather disease germs and many cases of typhoid fever can be attributed directly to them. Sanitary closets *can* be constructed and the retention of any other kind should be regarded as criminal. But wherever the latter are in use, they should be liberally treated with powdered borax.

Universal remedies of great importance, however, are never quickly adopted. The public is always slow to realize its own danger, legislatures are slower to enact sanitary laws, and executive authorities are still slower about enforcing them. So, from the first perception of a preventable danger to the last safeguard against it may be a matter of a century.

However, each individual can protect himself to a large degree from the danger of flies. In every possible way keep flies from food, and refuse to patronize restaurants and bakeries where food stuffs are exposed to flies. Rule 9 of the State Pure Food and Drug Department provides for the protection from flies of food offered for sale, but the flies pay little attention to this rule in Indianapolis—they may be seen most anywhere in bakeries and lunchrooms wandering freely and undisturbed over pies, cakes and cooked fruits or anything else that appeals to their taste, but of course the flies don't know any better.

Flies are known to carry the germs of infantile diarrhea, and the high mortality of bottle-fed infants may be in large part

attributed to the contamination of feeding bottles by flies. Infantile paryalisis also is now said to be transmissable by flies.

Some writers recommend the use of pyrethrum for flies in houses. Pyrethrum is a yellow insect-powder, called also "buhach", but most frequently sold by druggists under the name of "Persian insect powder." The powder will burn slowly if a cone-shaped pile is put on a dish and a lighted match held at the top, and will then give off thick pungent fumes which, so it is said, will stupefy flies when shut up in a room, causing them to fall to the floor where they can be swept up and destroyed. However, an experiment made by the writer gave no such results. After two hours the flies were still as active as ever though the room was filled with clouds of yellow smoke that caused much smarting to the eyes and throat of any person who ventured in. Even when the fuming dish was held directly under them no flies showed any symptons of asphyxiation. The smell of the smoke remained strong in the room all night.

But the druggist who sold the pyrethrum used in this experiment had kept it in an open box under which condition it rapidly loses its effectiveness. Others have reported entire success with pyrethrum as a fly remedy, but the powder must be genuine and fresh or kept by the dealer in a tightly closed container, and unless it can be obtained thus the housekeeper will have to be content with such old-style remedies as screens, fly-papers, fly-poisons and fly-traps. A very effective poison may be made by adding a little formalin and sugar to a dish of water. It should always be remembered, however, that poisoned liquids sitting about the room are as likely to be sampled by children and pet animals as by the flies, though formalin has a repellent odor at close range which gives it an advantage over tasteless arsenical poisons which are used in the preparation of "fly papers".

We used to be taught that all creatures were made to contribute in some way to man's welfare, and that flies should be endured on account of the decaying things they devour, being thus useful scavengers. But we now know that every species lives for its own ends, and that the normal state of all living nature is a continual war for existence. Man, therefore, asserts his right to live only by the mastery of his natural enemies. The harm done by one fly will offset the good done by a million. While flies may not be directly inimical to us they are guilty of gross criminal carelessness and so have no claim for mercy.

Flies themselves are not uninteresting creatures. They are of

versatile temperaments, being equally at home in all kinds of surroundings. While they seem at times to seek out filth assiduously they are at others equally partial to the cleanest dining room. In fact they freely go from one to the other. They are more cleanly in their personal habits than might be expected from them, but they are just as likely to sit on your cake or your salad to clean themselves as anywhere else. The "specks" which they drop everywhere are often full of disease germs of many varieties.

The average life of an adult fly lasts for two or three weeks though some live much longer than this. The females do not usually begin laying eggs till from 4 to 14 days after becoming adult, but each may deposit one or two hundred eggs at least before she dies. Generations may follow each other a month apart through the entire season, while during the warmest weather only about two weeks may intervene from the egg-laying of one generation to the egg-laying of the next. Recent tests have shown that the winter is passed in the pupal stage in cold climates and not as hibernating adults, for none have been kept alive longer than 91 days under very favorable circumstances, as most die within a month or so.

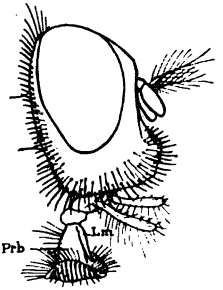

Fig. 41.—HEAD OF HOUSE FLY, GREATLY ENLARGED
Showing the proboscis (*Prb*) with two rasping pads at the end. The fly has no jaws and can eat only liquid or dissolved food, which is sucked up through the passage beneath the labral flap (*Lm*).

The true house-fly can feed only on liquid foods or on solids like sugar which it can first dissolve with saliva from its mouth. The mouth is provided with a short thick proboscis (fig. 41, *Prb*), having two wide soft lobes at the end on which are roughened ridges that give it a rasping surface. The liquid food is sucked up through a groove on the front surface of the proboscis covered by a slender horny flap (*Lm*).

House-flies, therefore, cannot bite. The fly that does bite and which is commonly mistaken for the house-fly is the one

called the stable-fly. This species is very similar to the house-fly in general appearance, but its mouth is provided with a long, slender, horny proboscis, which makes a very effective piercing organ. The stable-fly is noticed especially before storms, and consequently people think that the ordinary fly is particularly given to biting at such times.

Another well-known fly is the big greenish-blue fellow that frequently gets into houses and buzzes about in a very important manner. These are commonly known as "blue-bottle-flies". They are not numerous enough to be a bad pest, but like the house fly their habits out of doors are very uncleanly, and their favorite resorts are any kinds of putrid matter. People used to think that the flesh of dead bodies turned into worms, since all observed the thousands of maggots that soon swarmed in decaying carcasses, but this is, of course, not so. The maggots are simply the larvæ of flies, mostly of the blue-bottle varieties, called also "blow-flies", and they would not appear unless some fly had had access to the carcass and laid her eggs thereon.

One more member of the house-fly tribe should be mentioned, and this is the cluster-fly. Occasionally reports come in of a fly that comes into the houses in large numbers during the fall and collects in bunches or crawls about in a listless way, especially in unused rooms or attics. These are the cluster-flies. They are a little larger than the house-fly and in repose hold the wings more parallel with the sides of the body. They do no particular harm but their presence is never desirable.

Probably the simplest way to get rid of cluster-flies is to burn a little fresh pyrethrum (Persian Insect Powder) in the room. This will stupefy them so that they may be swept up and burnt.

HORSE-FLIES

The typical and best-known member of this group of pests of horses and cattle is the large black fly that settles on horses and severely bites them; but there are nearly three hundred species of the horse-fly family in the United States.

It is only the females of the species that bite animals, the males feed on the juices of plants and on the honey dew of aphids, though both sexes have strong piercing mouth-parts. While the emales are always blood-thirsty they can subsist like the males on plant juices. They are especially active in hot weather.

The eggs are laid on the stems and leaves of plants in wet

places or over water. The larvæ hatch out in from seven to nine days and drop to the ground or into the water. Some species live in the ground near the water, others in rotten logs and still others as free swiming larvæ in water. They are all voracious creatures feeding on earthworms, other insects and even on one another. In the spring the larvæ of all species so far as known, enter the ground to transform to pupæ from which the adults emerge after three or four weeks.

The horse-flies are called a'so gad-flies and some smaller species are known as deer-flies. Their bite is painful but does not produce a sore because there is no poison injected.

BOT-FLIES AND OX WARBLES

The bot-flies, in the larval stage, are parasites of domestic and other animals. The bot-flies of the horse live in the stomach, sometimes in great numbers (fig. 43) attaching themselves to the stomach walls by means of a pair of mouth hooks. The adults

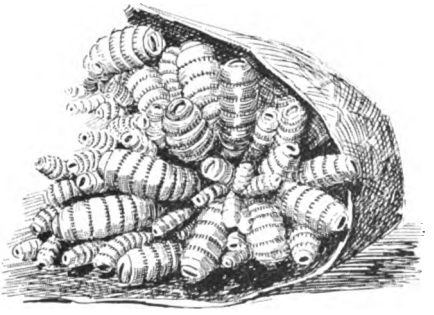

Fig. 43.—BOT-FLY LARVAE IN THE STOMACH OF A HORSE.
(From photograph. Osborn, U. S. D. A.)

are dark brown furry flies, somewhat larger than a blue-bottle fly, having transparent wings with dark spots. There are several species of them but they all have similar habits.

The females of the commonest species lay their eggs on the hairs of the horse's legs, shoulders or other parts where the young maggots are likely to be licked off as soon as they hatch and thus taken into the mouth. Two other species lay their eggs about the chin and on the lips and the long hairs around the mouth. One of these known as the "chin-fly".

The young larvæ, when they find themselves in the mouth, travel down the gullet and enter the stomach where they firmly

attach themselves to its walls and grow to maturity. They are somewhat bottle-shaped, the head end being small and tapering while the free end is obtuse and flattened. Each segment is surrounded by a row of spines pointing backward. The larvæ live in the stomach from fall till spring and when they are then fully grown they relax their hold and pass to the exterior through the intestine. Here they burrow into the ground a short distance, transform to pupæ and after a few weeks emerge as adults.

The best preventive for horse bots is to keep the horse free from the eggs. This of course requires constant watching, but it is said the eggs may be easily removed by rubbing with kerosene or gasoline. Internal remedies are used when it is suspected or known that the parasites are present, but they should be prescribed by a veterinarian.

The parasites of cattle known as warbles are close relations to the bot-flies of the horse. Frequent reports of this insect were

Fig. 44.—LARVA OF AN OX WARBLE, ENLARGED ABOUT 1½ TIMES

brought to the office during last spring, and the warbles seem to be getting more numerous in Indiana than formerly. The presence of the pest is not observed until the open sores containing the maggots (fig. 44) are found along the back and sides of the animals. When full grown the maggots come out and fall to the ground, after which the sores heal over but the hides may be ruined for commercial purposes.

The adult of the warble maggot is a yellowish-brown fly resembling a honey bee in general appearance. The females lay their eggs in the summer and fall on the legs, backs and sides of cattle, securely attaching them to the hairs by a gluey substance extruded along with each egg. The larvæ hatch in about a week and the animal gets many of them into its mouth when licking itself. These tiny creatures attach themselves to the walls of the gullet and proceed to bore through its lining or mucous membrane to its muscular layers. Here they remain and grown during the fall, but in winter they travel outward through the muscles of the gullet and through the connective tissues of the

neck and back muscles to the soft tissue beneath the skin of the back. Here their presence may be observed as early as midwinter by the lumps they produce, in which later they bore holes for breathing purposes, thus producing the open sores in which the live maggots may be seen till they are full-grown.

It is said that some of the larvæ on hatching from the eggs penetrate the skin from the outside of the body and thus arrive more directly at their destination beneath it. The other method, however, is regarded as the more usual one, and is so perhaps on account of the toughness of the animal's hide.

When the maggots are full-grown they push themselves out of the holes in the skin and fall to the ground. Here they burrow beneath the surface, pupate, and by summer the adult flies begin to emerge. The eggs laid by the females in the summer and fall produce the maggots that mature the following spring.

When warble sores are discovered on cattle the maggots should be squeezed out and killed, or the younger ones may be killed in the skin by dropping a little turpentine into the cavities. It is said that in England a small bounty is offered for the maggots in an effort to exterminate the species. Such methods will at least reduce the number of individuals that would otherwise live to produce more, and an extensive cooperation could undoubtedly give appreciable results in this country, but no general effective remedy for warbles has yet been devised.

BEDBUGS

Bedbugs belong to the same order of insects as the plant-lice, and have piercing and sucking mouth-parts very similar to those of the aphis shown in figure 3. They feed only on blood and their favorite victims are human beings. Several other related insects that infest poultry and other animals look like bedbugs and are frequently mistaken for them.

The female bedbug lays her eggs in crevices of the bed frame, in corners of the mattress and in cracks about the wall and floor. The very young are pale and almost transparent but they become red as they grow and gorge themselves on blood. Their growth depends on the amount of food they are able to obtain. Ordinarily they mature in five to seven weeks, but many take three or four times as long as this under unfavorable circumstances. They will live a long time without any food at all.

The flatness of the bugs permits them to hide away in very

small cracks, and housekeepers often fail entirely to find them during the day, while at night they cause great annoyance by their presence; but in such cases it is certain that the pests are somewhere in the bed or about the room during the day. In applying remedies it is best to assume that the bugs are everywhere. Pour gasoline, or any commercial exterminator used, into all the cracks of the bed and around the edges of the matress, into the cracks of the floor, beneath the baseboard, and wherever the insects *might be* in hiding. Iron and brass bedsteads and springs may be very effectively rid of both the bugs and their eggs by pouring boiling water over them. This can be done by placing the parts in a tub or taking them out of doors. However, all parts of a bed may be thoroughly free from the pests but if the bugs are still in the room no permanent relief will be had from them.

Persistent cleaning, the use of gasoline, boiling water or any effective exterminator every week will keep the pests in check and in most cases will eventually get rid of them. However, the bugs rapidly travel from one room to another and will go even from one house to another, so that anybody is always in danger from infested neighbors. Then, too, there is the daily possibility of bugs being unsuspectingly brought into the house in market baskets, traveling bags, or on the clothing, for they can be picked up anywhere in hotels, work rooms or even on street cars. One female containing fertilized eggs could soon establish a considerable infestation.

In bad cases fumigation with hydrocyanic-acid gas is resorted to, but this is a deadly poisonous substance and the treatment should be conducted only by an experienced person. As an exterminator, however, the gas has no equal. It is not ordinarily explosive, though it is recommended not to have fires in the house while it is being used. It will not bleach or tarnish anything but nickle plating. It will not poison dry food and only milk, butter or any liquid food is likely to absorb it. Several cases of death, however, resulting from careless manipulation have been reported in other places.

The gas may be generated from either potassium or sodium cyanide and dilute sulphuric acid. The proportions for potassium cyanide are as follows:

Potassium cyanide (98%).....1 Avoirdupois ounce
Commercial sulphuric acid.....1 fluid ounce
Water.....3 fluid ounces

Potassium cyanide is said to be difficult to obtain at the present time in most places, but the druggists in Indianapolis report that they have potassium cyanide in stock and not sodium cyanide. If, however, the sodium cyanide is used, 1½ ounces of acid should be used to one of cyanide and 3 of water. The reaction should be made in a large earthenware jar or crock.

The procedure for fumigating is as follows: First measure the space to be fumigated, because each 100 cubic feet will require one ounce of cyanide. Thus, if a room measures 15x12x10 feet, it contains 1800 cubic feet of space and 18 ounces of potassium cyanide will be needed; and, therefore, 54 fluid ounces of water and 18 fluid ounces of sulphuric acid. The house must be deserted and all pet birds and animals taken out even if only one room is to be treated; and the gas should be shut up in it for five or six hours—the doors locked and everyone warned against entering. Fumigation is, therefore, not practicable in double houses or in apartments unless the entire building is vacated, because enough gas to be dangerous can seep through an apparently sound wall.

Proceed as follows to fumigate one room; take up the carpet or rugs at least from the middle of the room to prevent their being spattered by acid; close the windows but arrange them so they can be opened from the outside, and then, unless they are pretty fairly tight-fitting, stop the cracks with rags or stick strips of gummed paper over them; stop up the chimney or fireplace with rags or paper; place a thick matting of newspapers on the centre of the floor to protect it, and on this set the generating vessel which should hold at least a gallon for every pound of cyanide necessary. Now put the requisite amount of water in the vessel and then pour the acid in slowly so as to prevent boiling and spattering (*never pour the water into the acid*). Next measure out the potassium cyanide, put it into a paper bag and place this gently in the acid bath. Leave at once without waiting to see the reaction begin—to inhale the fumes is fatal. The paper bag is to give you time to get out of danger, but the acid will quickly eat through it. Close the door, lock it and stop the cracks. If the fumigation is started at nine or ten o'clock in the morning it should be allowed to continue until four o'clock in the afternoon. Then open up the windows from the outside, and let the entire house air out for at least an hour before occupying it.

In most cases it will be necessary to fumigate the entire house because the pests seldom confine themselves to one room;

but the same methods are to be followed as given for one room. Stop up all cracks and fireplaces as well as you can. Place a generating vessel in each of the rooms and larger hallways, and mix the water and acid as before. Then measure out the required amount of potassium cyanide for each room, place each portion in a separate bag and set each bag beside the corresponding generating vessel. Begin at the farthest room upstairs to put the cyanide in the acid and work so that you will not have to pass through any room after the reaction begins. When all the bags are placed lock up the house for six hours and then ventilate before reoccupying.

If there are many windows and the cracks cannot be well-stopped a somewhat larger quantity of cyanide should be used in each. The one ounce to 100 cubic feet rule given above applies only to tight rooms.

The cost of fumigation will of course depend on the size of the house or the number of rooms to be fumigated, and will vary with the price of potassium or sodium cyanide. In the fall of 1916, chemically pure (C. P. or 98%) potassium cyanide cost 80 cents a pound wholesale in Indianapolis, and up to $1.25 a pound retail. Sulphuric acid costs 25 cents a pound. Three years ago potassium cyanide was 40 cents a pound.

A small seven-room cottage, including closets, hallways and bathroom is likely to contain about 12,000 cubic feet of space. Such a house, therefore, will require 120 ounces, or about 7½ pounds of potassium cyanide. This will cost from $5 to $9. The acid will amount to about $2, while seven gallon crocks or jars will cost $1.40, giving a total of from $9 to $14. A large house will of course contain much more space than 12,000 cubic feet and the cost will increase proportionally. Jars of three or four gallons capacity should be used in rooms requiring more than a pound of cyanide.

An equally effective fumigant and one much safer and more convenient to use is sulphur, but the fumes of burning sulphur have strong bleaching powers and are likely to fade some wall papers and cloth fabrics especially where there is any moisture present, and they will tarnish silver, gilt picture frames and metal fixtures. All such movable articles should be taken out of the rooms before fumigating and metal fixtures may be coated with vaseline. The danger of bleaching is least in a dry atmosphere.

Two pounds of sulphur is used to every one thousand cubic feet of space to be fumigated. Except for small spaces like

closets and pantries it is cheaper to buy powdered sulphur than sulphur candles. Put the sulphur in an old dish-pan and heap it up in a conical pile. Place the pan in a tub having the bottom covered with water, wet ashes, sand or earth in order to prevent the floor from being burned by the sulphur and as a precaution against starting a fire. Light the sulphur at the top of the pile. A little alcohol poured over it will make it easier to ignite. Close the room or house tightly for six hours or more.

Bedbugs have been accused of transporting disease germs from one person to another, but while they might do so, there is little specific evidence on which to convict them of this offense.

FLEAS

Fleas in the house breed on the floor, under the carpets, in crevices of the flooring, under the house, in the basement, in the sleeping places or bedding of cats and dogs, and out of doors on the ground.

The young fleas in such places are minute worm-like creatures, never seen unless a particular search is made for them. They have biting jaws and feed on any kind of animal or plant matter such as the dried pellets of blood excreted by the adult fleas, bits of hairs or feathers, and whatever is edible in the dust that collects everywhere in houses.

To exterminate fleas they must be attacked in their breeding places. The first measure is through house-cleaning. All dust and lint should be swept up and burnt for it may contain many young fleas in the worm stage. Next scrub the floor with strong soap suds, adding eight table spoons full of creolin to the bucket if the smell is not objectionable, or sprinkle it with gasoline when there are no fires in the house. Then scatter naphthalene, insect powder or buhack over the floor and replace the carpets.

Another method is to scatter about five pounds of fresh flake naphthalene over the cleaned floor of one room and close the room tight for twenty-four hours. Next day sweep up the naphthalene and use it over the same way in another room.

Fumigation by sulphur or hydrocyanic acid gas is sometimes resorted to, but should be done only by an experienced person.

All these methods will fail if the fleas are coming from the basement, from beneath the house, or from some outside source. In the basement or cellar the same methods may be employed as the house, thorough cleaning and liberal use of gasoline (when

fires are out) and naphthalene. If fleas are beneath or around the house clean up all rubbish and refuse and burn it. Then sprinkle salt on the ground and wet it, or use ordinary air-slaked lime.

To destroy fleas on dogs use creolin—making a 3% solution in warm water in a tub (4 tablespoonfuls of creolin to each gallon of water), and put the animal into it for 5 to 10 minutes, taking particular care to get its head and tail wet as well as all of the body and legs, for the pests will collect on any spot left dry. Small or delicate dogs should be washed after the creolin bath in warm water and soap to prevent burning the skin.

Cats may be injured by the creolin bath and the best treatment for them is to rub pyrethrum powder into their fur after placing them on a sheet spread out to catch the fleas as they drop off in a stupefied condition. Before the latter revive they should be gathered up and burnt. Pyrethrum may also be used on dogs.

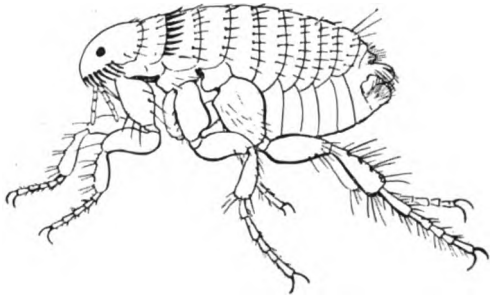

Fig. 46—A FLEA

A method recently discovered for ridding animals of insect pests is to place them in a tight box in which a few drops of nitrobenzene (oil of mirbane) are allowed to evaporate. This kills the parasites usually without hurting the animal, but more experiments are needed before the remedy can be generally recommended.

There are many different kinds of fleas but the commonest ones that molest people are the human flea, the cat and dog fleas and the rat fleas. They are all different species, but fleas do not confine themselves to their proper hosts. In the eastern part of the United States the ordinary fleas are the cat and dog fleas. But in California the flea that makes life miserable is the human flea. Rats are infested with two specific rat fleas but a

half dozen or more kinds, including the human flea and the cat and dog fleas, feed on them.

The mouth of the adult flea is provided with a set of piercing and sucking organs which enables it to feed on the blood of its victims but when the flea bites, it at the same time injects a small amount of an irritating liquid into the wound from its mouth. This causes a greater flow of blood for it to feed on and produces the swelling and itching of the wound.

Fleas lay their eggs on the hairs of their hosts, except the human flea but the eggs being unattached soon fall off. They hatch in from 2 to 12 days, depending on the temperature and moisture of the air. The young flea is a minute worm-like creature having a head and twelve body segments, without legs or eyes but with biting jaws. It lives in this stage from one to several weeks, even as long as 20 weeks, the time again depending on temperature and moisture. But when full grown it spins a thin oval web about itself and then changes to a pupa inside of it. In this stage they may remain from a week to a year emerging as adults when conditions are right for them. The adults probably then jump upon the first animal or person that comes in their vicinity. The human flea is the best jumper, in a horizontal direction it can clear 13 inches and the strongest can jump 7¾ inches high. In dry climates fleas can live only a few days without food, but they have been kept alive in moist places for 10 or 12 weeks without feeding. They are known to live five months or more under normal circumstances.

COCKROACHES

Since roaches are particularly fond of anything containing sugar, flour or starch it seems as if it should be a simple matter to kill them by mixing a powdered poison with one of these substances and scattering it about their runways. However, results are not so satisfactory in practice as they are in theory, and then, too, it is dangerous to have poisons strewn about the pantry shelf or lying loose around the kitchen, especially if there are children in the house.

Experiments have been made with substances that are not injurious to people and it has been found that some kinds of roaches are susceptible to borax, and that a mixture of two parts of powdered borax with one of powdered sweet choclate forms an effective

poison for the larger species, without being dangerous to human beings, dogs or cats. It is therefore to be recommended for use in bakeries and mills or wherever the larger kinds of cockroaches are found. In houses, however, a smaller species called the croton bug (fig: 48, E) is a more frequent pest and unfortunately it seems to be practically immune to borax.

A surer poison for any kind of roach is sodium fluoride. This may be mixed in a powdered form with three or four parts of flour, or used without any bait. Dust it over places the roaches are known to frequent, along their runways, and about holes in

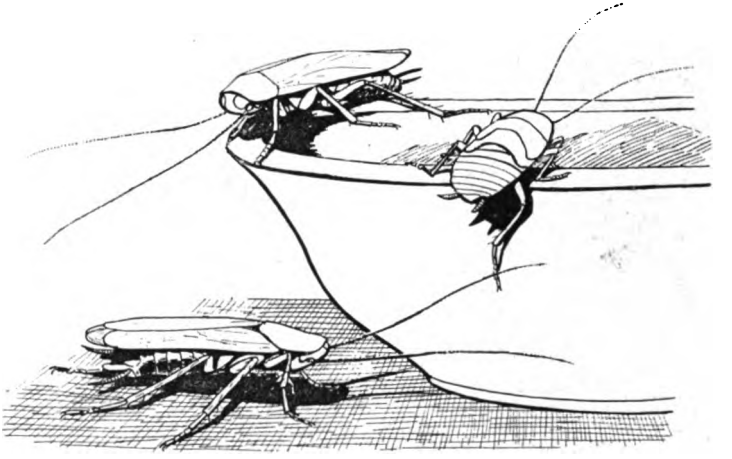

Fig. 47.—COCKROACHES

the walls where they enter the room. The poison has an irritating effect on the soft skin between the joints of the legs and body and the insects swallow it when attempting to clean themselves. Tests made by Mr. George D. Shafer at the Experiment Station of Michigan showed that roaches are killed by sodium fluoride in this way in from four to twelve hours.

Commercial roach powders containing phosphorus are often effective as exterminators, but all powders should be used plentifully and scattered about fresh every day or so till the pests are checked at least, and then continued less frequently till they disappear. Persistency and thoroughness in the use of any good powder is more to be recommended than the use of a violent poison. Put all food in tight containers where the roaches can not reach it and keep the pantry shelves and corners clean, for roaches are like tramps—they soon learn to avoid the places where they are not fed.

There are four varieties of household roaches which are now distributed over all the temperate and tropical parts of the world and are pests everywhere. The smallest one (fig. 48, E) is the insect commonly called the croton bug. It originally came from central Europe and is known as the German roach. The largest species (A), having well developed wings in the adult stage, is the American roach. A somewhat smaller species resembling the latter is the Australian roach. The larger blackish form with short wings, the female with scarcely any wings at all, is the Oriental roach (B, D), originally a tropical species.

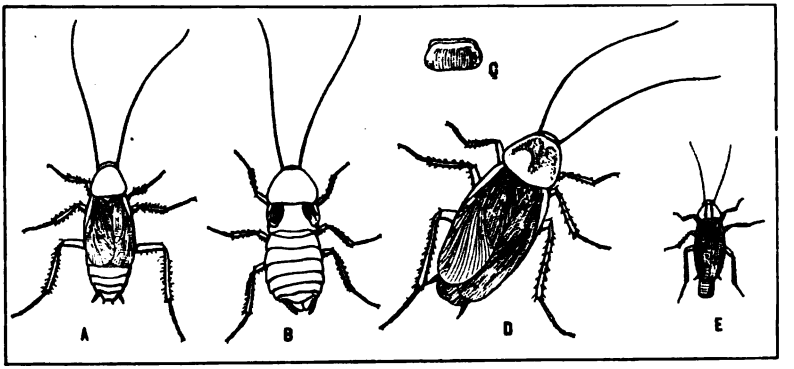

Fig. 48.—COMMON SPECIES OF HOUSEHOLD ROACHES, THREE-FOURTHS NATURAL SIZE

A, Oriental roach, male. B, Oriental roach, female. C, capsule of roach eggs as they are deposited by the female. D, American roach. E, German roach or croton bug carrying an egg capsule at the end of her body.

Roaches deposit their eggs in hard-shelled packages of a brownish color (C), each containing from 15 to 36 eggs according to the species. Often they carry the case about with them sticking from the rear end of the body for some time before dropping it.

Roaches being active creatures travel about from place to place and readily go from one house to another, so it is impossible to keep them out except by continual efforts against them.

PANTRY PESTS.

Besides such transient visitors to the pantry as ants and roaches there is a large number of other insects which live continually in food stuffs, especially the dryer sorts such as cereals, flour, meal, nuts and chocolate; and which breed and multiply in these materials if left alone.

One of the most common of pantry pests in Indiana is the Indian-meal moth, so named because it was first reported in Indian corn meal. It eats, however, almost all kinds of dry foods and infests not only pantries but mills, candy factories,

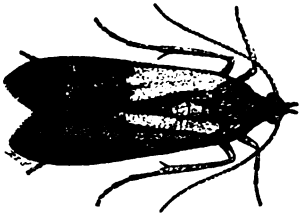

Fig. 49.—THE INDIAN-MEAL MOTH, ENLARGED 4 TIMES

stores, warehouses and granaries. The adult (fig. 49) is a small moth about three-eights of an inch in length. The terminal half of the wings is brownish-bronze in strong constrast with the pale color of the front half. The larvæ (fig. 50) are small whitish worms resembling an apple worm. They spin loose webs of

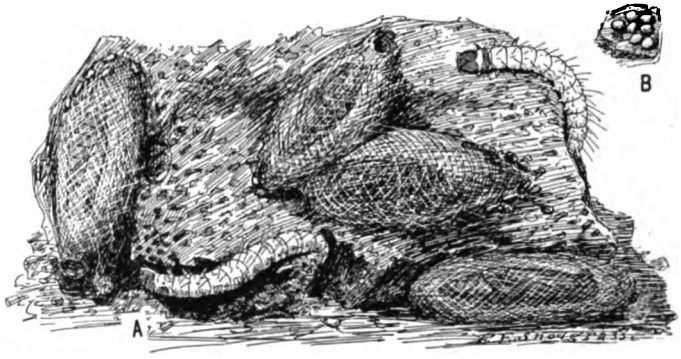

Fig. 50.—EGGS, LARVAE AND COCOONS OF THE INDIAN-MEAL MOTH
A, larvæ and cocoons on piece of dry bread, enlarged 2 times. B, a group of eggs.

silk wherever they go through the meal or flour and this causes a matting together of the particles—a condition well know to most housekeepers. When full grown the larvæ spin cocoons about themselves inside of which they transform to pupæ (fig. 50) from which later the adult moths emerge. The females lay their small oval eggs (fig. 49, B) on the food material. The eggs hatch in a few days and the whole life cycle from egg to adult may be completed within four or five weeks when the weather

is warm and food plentiful, so that there may be several generations produced during the year.

The best measure to be taken against this pest is to keep all food in tight containers. If infested material is received from the dealer it should be returned at once. There is always a chance of finding prepared foods infested because it is almost impossible to keep the insects out of most mills.

If the pests once gain a footing in the pantry they are likely to spread rapidly from one thing to another. Infested material should be either burnt or fed to the chickens. The pantry may be fumigated with sulphur which will kill any of the moths hiding about in cracks and corners. Sulphur candles are more convenient to use for small spaces than loose sulphur. One four-ounce candle is sufficient for 125 cubic feet of space. Place the candles in a dish-pan having the bottom covered with wet sand or earth and set this on the floor. Remove all silver and other metal ware which might be tarnished, and liquid or moist food. Light the candles and close the pantry tightly for six hours or more.

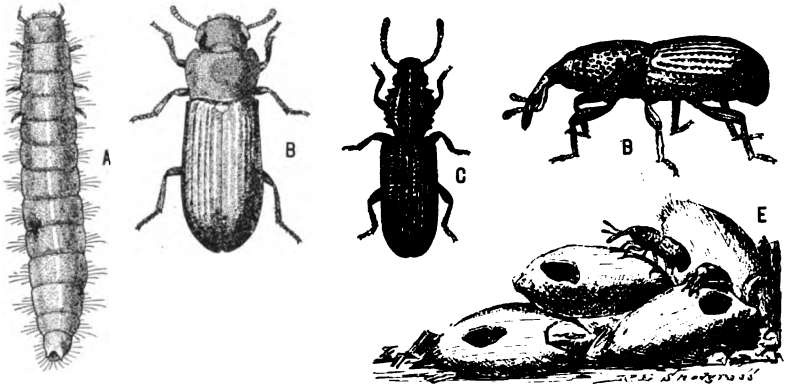

Fig. 51.—GRAIN, FLOUR AND MEAL BEETLES
A, B, larva and adult of confused flour beetle. C, the saw-toothed grain beetle, D, the granary weevil. All enlarged about 8 times. E, granary weevils in wheat, enlarged about 2½ times.

There are three other species of small moths having similar habits to the Indian-meal moth which are common in some parts of the country and likely to occur anywhere. They can all be treated by the same methods.

Besides the pantry moths there are several tiny beetles that live in dry food stuffs. They differ from the moths in that the adult

beetles as well as their worm-like larvæ or grubs live in the material infested, though of course they spread also by crawling about or flying from one thing to another. Two species are very common in Indiana. One is the confused flour beetle (fig. 51, A) and the other is a saw-toothed grain beetle (fig. 51, B). Then, too, there are the grain weevil (fig. 51 C), and the rice weevil, somewhat larger blackish beetles with the head prolonged into a snout. The weevils are especially likely to occur in flour, though they infest almost anything else and are particularly common in stored grain.

Infested material should be discarded—burning is safest. Weevils can be sifted out of flour, but most people do not like the idea of eating anything that has had insects in it. The use of

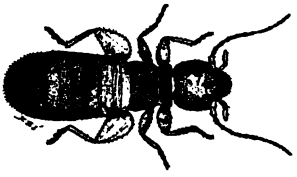

FIG. 52.—A BOOK-LOUSE, GREATLY ENLARGED

fumigants such as sulphur and carbon bisulphide is less satisfactory against beetles than for moths, since many species are able to resist poisonous fumes for a long time.

In any case preventive measures are better then remedial ones. Food kept in tight jars or cans is proof against infestation if clean when received from the dealer.

Last fall we found a small insect commonly called a book-louse (fig. 52) present in great numbers in a pantry in Indianapolis. They were in everything besides being all over the shelves and dishes. Book-lice ordinarily infest straw but when found in houses they usually occur in books and old papers. They readily succumbed to sulphur fumes in the pantry.

GRANARY INSECTS

The same pests that infest cereals in pantries are enemies of stored grain, but those that do the most harm are the beetles. These are the granary weevils, the confused flour beetle, the saw-toothed grain beetle (fig. 51) and several other species.

The usual remedy recommended for granary pests is the use of carbon bisulphide at the strength of three or four pounds to every

1,000 cubic feet of space. Carbon bisulphide is a liquid that rapidly evaporates into a heavy, vile-smelling, poisonous gas which is highly inflammable. So when using it never have any kind of fire near, not even a lighted pipe or cigar. It is said that sometimes even it may be ignited by an electric light. It should be poured into wide pans and set on top of the material to be fumigated so that the heavy fumes will sink downward through the grain. The bin should be as nearly air-tight as possible and closed for forty-eight hours.

Some insects are very susceptible to the fumes of carbon bisulphide and others are not. In any case the treatment works best in a warm temperature, 70° Fah. or over, because evaporation is more rapid then. But even so, some species seem to resist the poison, or the majority of the individuals may be in the upper part of the grain while the heavy gas sinks to the bottom part, or they may be protected by the mass of fine material that accumulates where they have been feeding. Mr. A. A. Girault, in a report from the experiment station of Illinois, concludes as a result of his experiments that nothing short of ten pounds of carbon bisulphide to every thousand cubic feet of space is effective on all species under all conditions and in any temperature. In fact the whole subject of killing insects in stored grain is in an unsatisfactory state, and more tests and experiments must be carried on before entirely reliable recommendations can be made.

Hydrocyanic acid gas has been used in granaries and mills, but being such a deadly gas it is suspected of leaving some poisonous effect on the grain, though tests have proved that this suspicion is unfounded. The fumes of sulphur have been shown to injure the baking qualities of flour. It also destroys the germinating power of seeds when used strong enough to kill insects. The most effective remedy against granary and mill pests is high artificial heat—118° to 125° Fah. maintained for several hours. Especially is this treatment destructive to insects if it can be followed by a freezing temperature. The heat method has been used with entire success in mills where a high temperature can be maintained, but in most cases it is entirely impracticable.

PEA AND BEAN WEEVILS

Stored beans and peas are often found badly infested with small grayish-brown beetles less than one eight of an inch in length. Those are the pea and bean weevils.

The pea weevil (fig. 53) may be distinguished from the bean weevil by the presence of a small spine on each side of its thorax. While the adults live through the winter in the dry peas they do not breed in them. In the spring the females lay their eggs out of

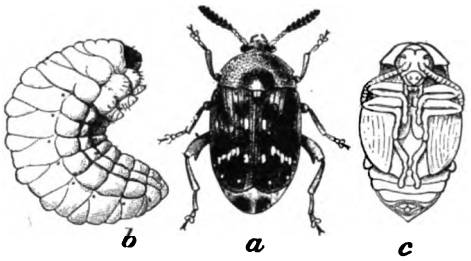

Fig. 53.—THE PEA WEEVIL, ENLARGED 5 TIMES
a, The adult beetle. *b*, The larva. *c*, The pupa.
(From Banks, U. S. N. M.)

doors on the very young pods of the new peas. The tiny larvæ on hatching are worm-like and immediately eat their way through the pods and into the kernels. Here they live and grow, changing into pupæ and then into adult beetles.

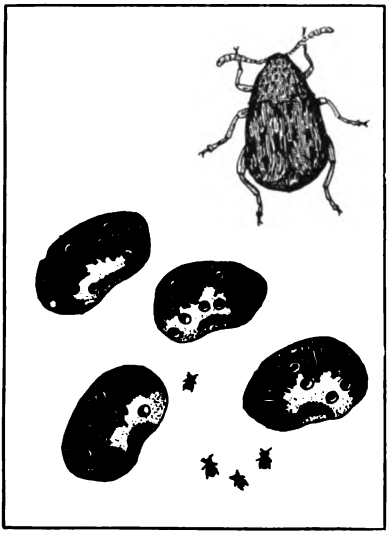

Fig. 54—THE BEAN WEEVIL
Upper picture, the adult weevil enlarged 7 times. Below are shown infested beans and weevils in natural size.

The adult beetles usually remain in the peas all winter, continuing to feed on them till spring, but they will not lay their eggs on dry peas, so unless they can escape in the spring they will all die the second year. Therefore, by keeping seed peas over one season no living weevil will remain in them. But if peas intended for seed are put into water most of the infested ones will float and can thus be separated from the sound ones. The best remedy for weevils is fumigation, described farther on.

The bean weevil (fig. 54) is about the same size and same general color as the pea weevil, but its body tapers forward and the sides of the thorax have no spines.

In bad cases of infestation in stored beans great numbers of them may be found and every bean may have from six to a dozen small round holes in it as if hit by a charge of bird shot. The beans will crush easily between the fingers, their interiors being entirely eaten out and filled with a fine dry powder.

The bean weevil is a worse pest then the pea weevil because it keeps on breeding and multiplying indefinitely in stored beans, though, in the spring, the females naturally lay their eggs on the young bean pods. They generally cut slits through the pods with their jaws and insert the eggs through these. The larvæ live and change to pupæ inside of the beans, as do the pea weevils, and the adults hatch out and continue the destruction.

The females that emerge while beans are still on the vines escape and lay their eggs in other pods, but the later ones remain in the beans and lay their eggs on or in the latter. When the next generation matures the beetles probably find themselves in dry stored beans but they lay their eggs in these and produce another generation, all feeding on the beans, and in the course of a year, from three to six generations may be produced depending on the climate. So it is little wonder that when the beans are examined they consist of mere shells filled with the beetles and the fine dry powder they produce from the bean tissues.

Seed beans may be tested the same way as peas by putting them in water—the infested one will float. Destroy the latter and use only the sound ones.

Beans stored for food may be treated with carbon bisulphide when an infestation of weevils is discovered. A tight barrel such as a vinegar barrel holding about 5 bushels may be used. Pour 4 ounces or more of carbon bisulphide into a dish, place it on top of the beans and close the top as tightly as possible. If no other means is at hand lay sacks over the top and place boards over these heavily weighted down. Leave for forty-eight hours and then thoroughly air. Be careful not to ignite the fumes by a pipe or cigar—they are explosive. Beans thus treated are not damaged either for planting or eating. Fumigation will be found most effective when the temperature is 70° Fah. or more. In lower temperatures use more carbon bisulphide.

For commercial purposes of fumigating on a larger scale some sort of a fumigator is constructed in the form of an air-tight box or small building with a tightly closing door. Three or four pounds of carbon bisulphide will fumigate 1,000 cubic feet of air space and should be allowed to act for 36 to 48 hours.

Besides these two weevils there are several other species related to them. One is the cow-pea weevil which attacks principally the cow-pea but it is found also in other peas and beans. The European bean weevil is often found in imported beans. Then there is a large number of native species which feed on the seeds of wild flowers.

CLOTHES MOTHS

The small yellowish moths seen flying about the house during the spring and summer commonly called "moth-millers" are likely to be clothes moths and housekeepers do well to catch

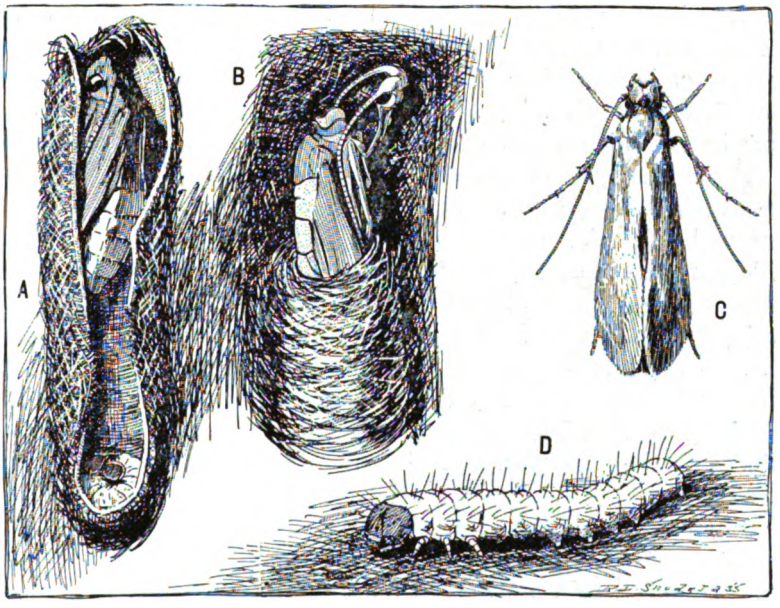

Fig. 55.—THE CLOTHES MOTH, ENLARGED 6 TIMES
A, cocoon cut open showing fully formed pupa within. B, empty pupal skin projecting from door of cocoon after the moth has emerged. C, adult moth. D, the larva which does the damage to clothes.

and kill as many of them as possible, because they lay the eggs on clothing from which hatch the small worm-like larvæ (fig. 55, D), that do so much damage later in the season.

However, it would be a hopeless undertaking to attempt an extermination of the moths themselves, they will keep on coming no matter how many are killed, just like flies. The real fight must be to prevent the moths from placing their eggs on clothing,

on blankets or on any woolen goods to be stored away for the summer, and to kill the larvæ before they have done any harm.

Moth-balls, naphtha, camphor, cedar and such things are at best only good for keeping the moths away from clothes. The moths do not like the smell of these things, but the larvæ have no objection to them at all, and if moth eggs are already laid on garments or blankets stored away in cedar chests or packed with moth balls or camphor, the larvæ will hatch just the same and feed and grow, causing as much destruction as if the odors were not present.

Before putting clothes away brush them thoroughly and hang them out in hot sunshine for several hours. Then place them in trunks with moth balls or camphor, or, better still, in moth-tight chests, or seal them up in moth proof bags. But you can never be *sure* of having cleaned off all the eggs. Therefore, examine the garments again after a few weeks to be certain they are free from larvæ which may have hatched out in the mean time.

If the pests should be discovered the best thing to do is to put the article loosely into a tight trunk or chest and fumigate with carbon bisulphide. Pour a small quantity of this liquid into a wide pan, set it on top of the things in the chest and close the latter for two days. This will kill the worms and is most effective during warm weather. The fumes have a very unpleasant odor and are explosive so do not have any lights or fire near them. The liquid may leave a yellowish stain of sulphur if spilled on anything, so it is best to put a newspaper beneath the pan containing it, but the fumes will not bleach or cause any other damage.

A very convenient method recommended where a chest is used for summer storage is to bore a small auger hole in the top through which a little carbon bisulphide may be poured several times during the season, first having placed a large wad of cotton beneath the hole to absorb the liquid. Plug the hole with a cork. This will insure against damage by larvæ possibly overlooked in the earlier inspection and will serve to make assurance doubly sure.

The moths do not attack clothes that are being frequently used, but the pests may be found in garments left hanging in a closet for several weeks. The closet may be fumigated by placing a dish of carbon bisulfide on the *top shelf* and keeping the closet shut for forty-eight hours. The cracks about the door should be

stopped as tightly as possible with rags. Do not come near the fumes with a light since the gas is explosive.

There are two common species of clothes moths, both of which look much alike. The larva of one constructs a tubular case about itself as it works, made of silk which it spins from its mouth and of fibers from the material on which it is feeding. The other makes long galleries and runways of silk, thus leaving its trail wherever it has been. Each kind eats holes in the garments and many utterly ruin them in the course of a season.

During winter the pests are less active than in warmer weather and many of the larvæ crawl off into secluded corners and cracks where they spin cocoons within which they pass the cold season in a resting condition as does the codling moth worm of the apples. Late in the winter or in early spring they transform to pupæ (fig. 55, A). In about two weeks the pupa matures and the moth is ready to emerge. But first the pupa wriggles itself out of the door which the larva left open in the front of the cocoon. Then the skin splits at the head end of the pupa and the adult moth (c) emerges, leaving the empty pupa skin projecting from the door of the cocoon (B).

The female moths soon find the wardrobe where they seek out woolens, furs or feathers on which to deposit their eggs. From them the young larvæ hatch in about nine days and begin the season's work of destruction unless checked by artificial means. There are probably several generations of the pests each year.

CARPET BEETLES

The common pests of carpets are two kinds of soft, hairy insects about a quarter of an inch long when full grown. Each is the young or larval stage of a small, hard beetle which lays its eggs on the carpets but does not eat them itself.

Both species of carpet pests are shown in the accompanying cut (fig. 56). One (A) is slender, tapering backwards, and has a large tuft of long hairs at the posterior end. The other (C) is thick at the middle and hairy all over. Both are brownish in color. The first is the young of the black carpet beetle (B); the other is the young of the ordinary carpet beetle (D) and is often called the buffalo bug.

The pests sometimes eat irregular holes in the carpets but more often they make long slits on the under side following the cracks of the floor. Besides carpets they eat woolen goods of

any sort, also silks, furs, feathers in pillows, and are often found in flour, meal and other cereals. The adult beetles feed on the pollen of flowers and must escape from the house in order to do so, but they probably lay their eggs before leaving.

Infestations by these pests are frequent. Their work in woolen clothing is often mistaken for that of the clothes moths. While the beetles may at any time fly into the house from the outside they probably do not often start an infestation in this way. A bad case of them can usually be traced to some article brought in which, though not suspected at the time, contained larvæ or eggs which soon hatched and spread to other things.

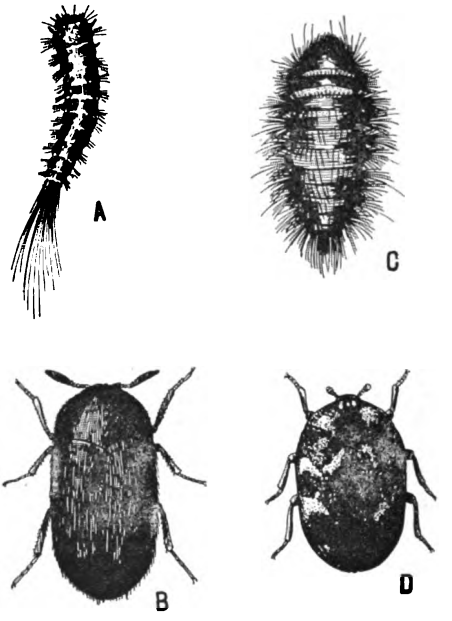

Fig. 56.—CARPET BEETLES, ENLARGED ABOUT 4½ TIMES
A, B, larva and adult of black carpet beetle. C, D, larva and adult of the buffalo bug.

Once established there is no easy way to get rid of these pests, especially if the floors are covered by carpets. Rugs and bare floors offer much less difficulty. In any case the floor-covering must be taken up, thoroughly beaten, sprayed with gasoline, and allowed to hang out of doors several hours. Wash the bare floors with hot water and soap, clean out the cracks and pour kerosene or gasoline into them and under the baseboards. Have no fire near while doing so, in order to prevent an explosion of the evaporated gas. After this fill the cracks with crack-filler wax for cracks are the places where the insects thrive best. Carpets can be protected very much by placing tar paper between them and the floor.

If only one house-cleaning is done during the year, do this in mid-summer for it is then that the pests are worst, but two house-cleanings are better than one, and two will probably be necessary if the infestation is bad.

If the insects are in rugs, woolens, silks, furs or anything

smaller than carpets they may be killed by putting the infested articles into a tight chest or trunk and treating with carbon bisulphide. Do this on a warm day when the temperature is 70° or above. Pour the liquid into a wide dish and set it on top of the things in the chest. Close tightly for forty-eight hours and do not allow a light near the fumes for they are explosive. Closets may be fumigated in the same way—put the dish on the top shelf because the fumes sink in the air instead of rising.

Besides the two domestic species of these insects here described there are many others of similar habits, but they may all be treated by the same methods.

THE SILVER-FISH

This is a household pest of literary tastes—that is to say it shows a special fondness for libraries, but its interest in books goes seldom deeper than the covers. In fact it is the paste and glue that holds the backs together by which it is attracted, and

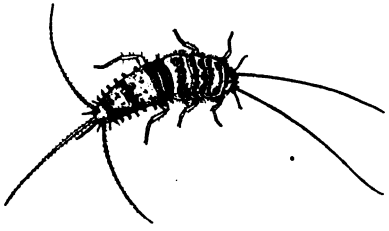

Fig. 57.—A SILVER-FISH, TWICE NATURAL SIZE

it will feed in other places where dry starchy material may be had, for such material constitutes its principal food and it will even attack starched clothes and curtains in order to appease it appetite.

One seldom gets more than a fleeting glimpse of these pests for when disturbed they scurry off with most surprising speed, and it is only now and then when one gets mashed that a close inspection may be possible. The insects are flat-bodied creatures adapted to living in tight places. They have a pair of long antenæ on the head and three long tails at the hinder end, but none of them have wings. They are the most simply-constructed of all the insects and are assigned by entomologists to the lowest order in classification. Their color is silvery-gray and the body

is covered with tiny scales—hence the popular name of "silver-fish," though sometimes they are known as "fish-moths." But they are not moths at all and never change to anything else than just what they are. Their entomological name is Lepisma.

Now, the best way to kill these pests is to take advantage of their paste-eating habit. Take some common library paste, mix a little white arsenic in it and set this out on bits of cardboard distributed over their haunts about the book cases or the library shelves. If the use of paste is too extravagant a little starch or flour mixed up with water and poison would probably give the same results. Scattering pyrethrum or some other insect powder along their runways would have a repellent effect upon the pests though it would only drive them off to forage in other places.

Fig. 58.—WINGED MALE AND FEMALE TERMITES ISSUING FROM A COLONY IN AN OLD LOG

TERMITES*

These are the insects that frequently cause so much damage to woodwork in houses, especially to parts near the ground. Outside they destroy fence posts, telegraph poles, railway ties, piled lumber and, in fact, anything made of wood they are able to get at. They usually enter whatever they attack from beneath the ground, making small entrance holes, and then gnaw out tunnels and galleries all through it till at last the post, tie, joist or sill is reduced to a hollow shell. When it collapses the story of perhaps several years' secret work is revealed.

*Much of this discount is based on Bull. No. 94, Pt. II, U. S. Bureau of Entomology. Biology of the Termites, by Thomas E. Snyder.

In the Eastern states houses have occasionally been completely mined by termites while in Indiana floors and other parts are frequently so damaged as to render their replacement necessary. A few years ago the furniture in an office room at Indianapolis sank through the floor before it was known that the latter had been riddled by these insects. In this case, however, the floor rested upon the ground so that no danger was incurred, but in another at Pendleton the floor of a living room began to sag in an alarming manner and investigation showed that the joists had been completely destroyed by termite ravages.

Greenhouses are particularly subject to attack by termites on account of the warmth and moisture present. The pests destroy the wooden framework of the houses and riddle the boards of the benches. From the latter they often get into the plants themselves coming up through the holes in the bottoms of the pots and entering the plants from the roots.

Nursery stock frequently suffers from termites, pecan seedlings being particularly attractive to them. They enter the lower part of the stem and excavate the interior until only a shell of bark is left. Sometimes they eat apples lying on the ground and cases of damage of potatoes have been reported.

Termites are frequent pests also of libraries. Books on shelves are sometimes found to be invaded and eaten by them when left undisturbed during a summer vacation, while both books and documents stored in damp basements have often been completely ruined by them.

The insects themselves are small, soft-bodied, wingless creatures of a pale yellowish-brown color. They run about actively when disturbed but they are blind and very adverse to exposing themselves to light, though perhaps it is really the dryer air outside their galleries which is unpleasant to them. But whatever may be the reason for their seclusiveness, it is due to this trait that their work is so seldom discovered till the wood they are in is completely hollowed out and begins to collapse.

Termites are not primarily pests of houses and lumber, their favorite habitat is an old decayed log or rotten stump, while they construct their nests also under stones and boards lying on the ground. Their communities often reach a very large size, sometimes containing as many as ten thousand inhabitants or more.

Most of the individuals seen on exposing a nest are of the small, yellowish, wingless kind, but associated with them are many others having very large heads and long curved jaws. The former are

known as *workers* and the latter as *soldiers*. The workers probably do most of the work of excavating the galleries, since their smaller though strong jaws are more adapted to gnawing the wood than are those of the soldiers. The soldiers have never been observed to be of any particular use in the colony, but they are regarded as its possible defenders in case of need. Both the workers and the soldiers are of either sex but neither of them have the reproductive organs functionally developed.

The wood dust which the workers produce in excavating the galleries is the principal sources of their food. It is chewed up into a pulp and swallowed and whatever nourishment it contains is digested and absorbed on its way through the body. Large masses of it are continually voided from the alimentary canal, but in its reduced and compact condition it does not again fill up the galleries, leaving plenty of space as runways for the inhabitants and as brood chambers for the eggs and young. But this wood pulp is not the only source of the termite's food. They eat the cast skins of the young and are said also to be cannibalistic, the living eating the dead and the normal ones devouring the weak or injured and the young that are not able to shed their skins in moulting. This latter process is a precarious event with many insects for it often happens that the moulting individual is too weak to extract itself from its skin or that the skin dries so quickly that the insect is not able to complete its emergence.

The workers, however, must swallow much more pulp than is needed for their personal sustenance. Some of it, therefore, when voided still contains nourishing matter and, indeed, on account of the alimentary juices mixed with it, must be in a better state for digestion than when first eaten. This excrement is made use of as food for the young, the feeding of the brood being a part of the duties of the workers. It is likely also that the soldiers feed on it because they probably do little if any of the work of excavating. Besides this food material the young are fed also another predigested substance which, it is said, the workers regurgitate from their stomachs.

The eggs from which all the members of a colony are hatched are laid by one or several reproductive females with greatly enlarged abdomens in which the ovaries are very highly developed. These egg-laying females are known as the *queens*. Associated with them are an approximately equal number of fertile males called *kings*.

During the spring and early summer an enormous number of

winged individuals appear, leaving the nests in great swarms through some hole or crevice. They are blackish-brown in color and resemble winged ants (fig. 59), and, as is the case with the ants, they are the males and females that have just reached maturity. After emerging from the nest they fly or are blown about in all directions, and those that are not eaten by birds or

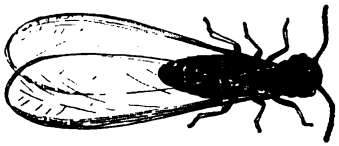

Fig. 59.—A WINGED TERMITE, ENLARGED 5 TIMES

otherwise destroyed mate in pairs and become the possible founders of new colonies. First, however, after alighting, they break off their very fragile wings by twisting the body or by rubbing against some hard object (fig. 60). The wings have served their purpose of dispersing these individuals from their original homes, thus securing the spread of the species, and are now but useless appendages better discarded.

Probably only a few out of the thousands that swarm ever survive, but when a successful pair has found a suitable location for a new home, a small cell is constructed in which copulation takes place and the female lays her first eggs. These hatch into small workers and soldiers, the former excavating more space

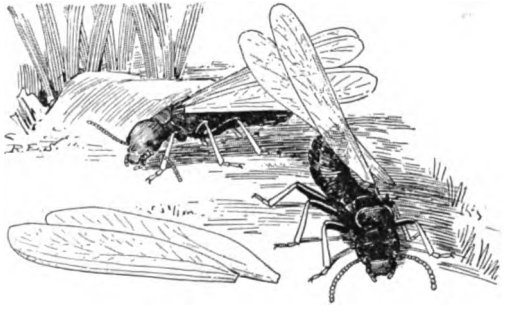

Fig. 60.—A PAIR OF TERMITES DROPPING THEIR WINGS

while the female lays more eggs, from which hatch larger workers and soldiers of usual size. The male is not discarded after the first union, as in bees, but remains as the active consort of the

queen. The abdomen of the latter increases greatly in size with age until it is many times its original dimensions.

The young in the first stage after hatching are all alike, and it is only in the later stages that they show the differences characterizing the workers, soldiers, and winged males and females. What causes them to grow up in these different ways is not known, but it is supposed to be due to differences in the food given to them by the workers, though experiments have not furnished much support to this theory.

The termites are always prepared against the possible loss of their queen, for otherwise her death would mean the discontinuance of the colony. Some of the young that would normally grow up into winged males and females are kept in a state of undevelopment, supposedly by the food given to or withheld from them, and in case the queen dies or is injured, these supplementary kings and queens are allowed to develop. They quickly attain sexual maturity but their wings never grow out and they do not leave the colony to mate. The emergency queens thus produced perhaps never reach the size of the original queen, but since there may be several of them instead of one the colony grows faster than before. It is probable also that most new colonies are formed as subdivisions of an old one maintained independently with these reared reproductive individuals, for swarming is a precarious adventure at best and the growth of a colony from a single pair is a slow process.

While the lives of these little insects are highly interesting to students of nature, an easy means of bringing about their destruction in places where they are not wanted is a thing greatly to be desired by lumber dealers, builders and householders. On account of their insiduous manner of working, the pests usually gain such a foothold in houses that the only way to get rid of them is to take out the infested parts and replace with sound lumber. But in such cases, unless the main body of the termite nest is discovered and destroyed no permanent good will be accomplished. To do this may involve tearing out a large part of the floor or of a wall, but it is the only remedy, unless the nest should be so situated as to be easily exposed, when fumigation by hydrocyanic acid gas sulphur or carbon bisulphide may be effective against the pests. If the infestation covers a small area the galleries may be opened by cutting into them, and the insects killed by pouring in kerosene or carbon bisulphide. It may be found in some cases that termites in a house may be traced to a

nest situated outside. If this can be located and destroyed the trouble may be ended.

Just how the insects might have gotten into an infested house is usually not possible to determine. A small colony of them may have been already established in some timber used in its construction; they may have been in the ground where the house was built; they may have migrated into it from some colony in the neighborhood; or finally, a mating pair may have selected some decayed board in it as a site for their new home.

It is said that coal-tar creosote renders posts or any timbers to be placed in contact with the ground immune to termite attack, but the treatment must be thorough, an uncovered crack will be sufficient to give the insects an entrance. Treatment with "blue oil" is said to be effective against them also. Wood intended for interior finish may be treated with chlorinated naphthaline (paradichloride of benzine) which seems, according to experiments, to render it proof against termites. This chemical does not stain the wood. However, most builders will probably perfer to take chances on the termites rather than resort to such extensive preventive measures. Boards or timbers or parts of a house only slightly infested but still fit for use might be subjected to a dry heat of 120° F. which is fatal to the insects. Some varieties of wood are naturally resistant to termite attack, but all such are tropical species, such as mahogany and teak.

Termite troubles, though. are seldom considered until the damage is done, and then the best thing to do is to destroy the infested boards, posts, ties, floor, joists, sill, wall or whatever the insects are in. The insects themselves will usually have rendered the part useless before they are discovered. Treatment for termites in houses will necessarily vary in each particular case, but it must always be the destruction of the pests, regardless of what else is involved.

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